PERIODICAL ROOM GENERAL LIBRARY MAY 15 1916 UNIV. OF MICH.


# ENGINEERING:

## An Illustrated Weekly Journal.

*EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.*

OFFICES FOR ADVERTISEMENTS AND PUBLICATION, 35 & 36, BEDFORD STREET, STRAND, LONDON, W.C.

VOL. CI.—No. 2626.] *LONDON: FRIDAY, APRIL 28, 1916.* [*Registered at the General Post Office as a Newspaper.*] [PRICE...6d. BY INLAND POST. 8d.



**Aveling & Porter, Ltd.,**
ROCHESTER, KENT,
and 72, CANNON STREET, LONDON.
STEAM ROLLERS. ROAD LOCOMOTIVES.
STEAM CULTIVATING MACHINERY.
STEAM WAGONS. TRACTORS.
CEMENT-MAKING MACHINERY. 4021

**A. G. Mumford Ltd.,**
CULVER STREET WORKS, COLCHESTER.
ON ADMIRALTY AND WAR OFFICE LISTS.
ENGINES for Torpedo Boats, Yachts, Launches.
BOILER FEED PUMPS.
See Advertisement, page 24.
PATENT WATER-TUBE BOILERS,
AUTOMATIC FEED REGULATORS,
And Auxiliary Machinery as supplied to the Admiralty. Od 2179

**Cranes.—Electric, Steam,**
HYDRAULIC and HAND.
of all types and sizes.
GEORGE RUSSELL & CO., LTD.,
Motherwell, near Glasgow. 4086

STEEL TANKS, PIPES, GASHOLDERS, &c.
**Thos. Piggott & Co., Limited,**
BIRMINGHAM. 4457
See Advertisement last week, page 79.

**Plenty and Son,**
LIMITED.
MARINE ENGINEERS, &c.
NEWBURY, ENGLAND. 9963

**Machine Tools in Stock:—**
Vertical DRILLS, to admit 18 in., 26 in., and 36 in. diameter. Bolt Screwing MACHINES. 10½ in. centre Special Shafting LATHE. Second-hand PLANER, 23 ft. by 6 ft. by 6 ft.
JAMES SPENCER & CO., LTD., 4360
Chamber Iron Works, Hollinwood, Manchester.

**Tank Locomotives.**
Specification and Workmanship equal to Main Line Locomotives.
R. & W. HAWTHORN, LESLIE & CO., LTD., ENGINEERS, NEWCASTLE-ON-TYNE. 4088

**Thread Milling Machines for**
DISPOSAL. Two, brand new, suitable for threading 6 in. shell, or smaller sizes. In Stock. Immediate delivery. Can be seen by appointment.—Address, E 60, Offices of ENGINEERING.

**One Powerful Economic**
MULTI-TUBULAR BOILER (Second-hand), 9ft. 9 in. dia. by 14 ft. 6 in. long, suitable for 160 lb. w.p. DESPATCH IMMEDIATELY. 5200
JOHN THOMPSON, Boiler Works, Wolverhampton.

**For Sale, National Gas Engine,**
"R" type, 23 H.P., in splendid condition; had little use, been kept for spare. Ready for removal end of May. Offers Wanted. Can be seen at Boston, Lincolnshire.
Address, E 70, Offices of ENGINEERING.

**Locomotives in Stock.—**
KERR, STUART & CO., LTD., have in stock or in an advanced state of progress at their California Works, Stoke-on-Trent, a large number of LOCOMOTIVES, with cylinders from 6 in. to 16 in. diameter (inclusive), for all gauges from 18 in. to 4 ft. 8½ in.—Apply to KERR, STUART & CO., LTD., 5, Broad Street Place, E.C. 4570

**Fuller, Horsey, Sons & Cassell,**
SPECIALISTS
in the
SALE AND VALUATION
of
PLANT AND MACHINERY
and
ENGINEERING WORKS. Od 1834
11, BILLITER SQUARE, LONDON, E.C.

**Invincible Gauge Glasses.**
*BUTTERWORTH BROS., Ltd.,*
*Newton Heath Glass Works,*
*Manchester.* Od 9758

**P. & W. MacLellan, Limited,**
CLUTHA WORKS, GLASGOW.
MANUFACTURERS OF
RAILWAY CARRIAGES AND WAGONS,
OF EVERY DESCRIPTION.
RAILWAY IRONWORK, BRIDGES, ROOFING, &c.
Chief Offices: 120, Trongate, GLASGOW. Od 8547
Registered Office: 108A, Cannon St., London, E.C.

**Yarrow & Co., Ltd.,**
SHIPBUILDERS AND ENGINEERS,
GLASGOW (formerly of POPLAR, LONDON),
SPEEDS UP TO 45 MILES AN HOUR.
PADDLE OR SCREW STEAMERS OF
**Exceptional Shallow Draught.**
VESSELS PROPELLED BY STEAM
**Turbines or**
**Internal Combustion Engines.** Od 8759

**Campbells & Hunter, Ltd.**
**Gear Cutting.**
Worm Wheels cut up to 15 ft. diam.
Bevel and Mitre Wheels planed up to 3 ft. diam.
DOLPHIN FOUNDRY, LEEDS. 4547

**Yachts, Launches, or Barges,**
Built complete with Steam, Oil or Petrol Motors; or Machinery supplied. Od 3551
VOSPER & CO., LTD., BROAD STREET, PORTSMOUTH.

**Cochran** MULTITUBULAR AND CROSS-TUBE TYPES. **Boilers.**
See page 76, last week. 5020

**Oil Fuel Appliances.**
SYSTEMS { PRESSURE, AIR, STEAM.
FOR BOILERS OF ALL TYPES.
**Kermodes Limited,**
35, THE TEMPLE, DALE STREET, LIVERPOOL; and
109, FENCHURCH STREET, LONDON. 4078
NAVAL OUTFITS A SPECIALTY.

**Locomotive Tank Engines**
designed and constructed by
MANNING, WARDLE AND COMPANY, LIMITED,
Boyne Engine Works, Leeds. Od 2487
See their Illustrated Advertisement page 85, last week.

**R. Y. Pickering & Co., Ltd.**
(ESTABLISHED 1864.)
BUILDERS of RAILWAY CARRIAGES & WAGONS.
MAKERS of WHEELS and AXLES of all kinds.
RAILWAY WAGONS FOR HIRE.
Chief Works and Offices:
WISHAW, near GLASGOW.
London Office:
3, VICTORIA STREET, WESTMINSTER, S.W. 9353

**Machine and Engineering**
WORK of all description undertaken for Manufacturers, Patentees, &c. Also repairs and renewals. Best work, moderate charges.—ROSSER & RUSSELL, LTD., Queen's Wharf, Hammersmith.
NEW PATENT ACT.—ROSSER & RUSSELL, Ltd., are prepared to undertake the manufacture of articles at present made abroad, and will be pleased to hear from firms desiring such work executed. 9211

**For Sale, One 275 Kw.**
Belliss GENERATING SET.
Compound wound Dynamo, 500 volts. Could be easily altered to 250 volts. Immediate delivery; cheap.
One 65 Kw. Gas-driven GENERATING SET, direct coupled Stockport Engine, Westinghouse Generator, 500 volt d.c. Engine would be sold separately.
One 87 HP. MOTOR, 500 volts, d.c. compound, 210 revs.
JENNINGS,
West Walls, Newcastle-on-Tyne. 4576

**The Glasgow Railway Engineering Company,**
GOVAN, GLASGOW. LTD.
London Office—12, Victoria Street, S.W.
MANUFACTURERS OF
RAILWAY CARRIAGE, WAGON AND TRAMWAY WHEELS & AXLES.
CARRIAGE & WAGON IRONWORK, also CAST-STEEL AXLE BOXES. 5055

THE WELL-KNOWN
**Fine Red Moulding Sand,**
FOR
IRON, BRASS, ALUMINIUM.
APPLY,
**Mansfield Sand Co., Ltd.,**
MANSFIELD, NOTTS. 5175

**John Bellamy, Limited,**
MILLWALL, LONDON, E.
GENERAL CONSTRUCTIONAL ENGINEERS. 1216
**Boilers, Tanks & Mooring Buoys**
STILLS, PETROL TANKS, AIR RECEIVERS, STEEL CHIMNEYS, RIVETED STEAM AND VENTILATING PIPES, HOPPERS, SPECIAL WORK, REPAIRS OF ALL KINDS.

**Tubes, Iron and Steel.**
**Edwin Lewis & Sons,** 4023
London Office:
143, Cannon St., E.C. **Wolverhampton.**

**Tubes and Fittings,**
—
**Stewarts and Lloyds, Ltd.,**
**Glasgow and Birmingham.**
See Advertisement page 48. 4000

**Improved High Pressure**
RENEWABLE DISC GLOBE VALVE.
See our Advertisement in last week's issue, page 20.
BRITISH STEAM SPECIALTIES, LTD.,
Bedford Street, Leicester. 3920

**80 "Thompson" Boilers**
IN STOCK.
One 30 ft. by 9 ft. 3 in. by 160 w.p.
Two 30 ft. by 8 ft. 6 in. by 160 w.p.
Two 30 ft. by 8 ft. 3 in. by 160 w.p.
Four 30 ft. by 8 ft. 3 in. by 100 w.p.
Two 30 ft. by 7 ft. 6 in. by 100 w.p.
Seventy other sizes and pressures.
**John Thompson,**
WOLVERHAMPTON. 4350

**Gas Engines, Suction Plants,**
Inspections, Tests and Reports. Expert advice.—E. J. DAVIS, M.I. Mech. E., Great Eastern Road, Stratford. Telephones: East 1360; Stratford 569. Tel.: Rapidising, London. 1794

**Cement.—Maxted & Knott,**
LTD., Consulting Engineers to the British Portland Cement Manufacturers, Ltd., ADVISE GENERALLY on proposed Cement Schemes FOR ABROAD. ADVICE ONLY. Highest references. Established 1900.
Address, BERNITT AVENUE, HULL.
Cablegrams: "Energy," Hull. 5234

THE GLASGOW ROLLING STOCK AND PLANT WORKS.
**Hurst, Nelson & Co., Ltd.,**
Builders of RAILWAY CARRIAGES, WAGONS, ELECTRIC CARS and EVERY OTHER DESCRIPTION OF RAILWAY AND TRAMWAY ROLLING STOCK.
Makers of WHEELS and AXLES, RAILWAY PLANT, FORGING, SMITH WORK, IRON AND BRASS CASTINGS.
Registered Office and Chief Works: Motherwell.
Cardiff Office: Gordon Chambers, 31, Queen Street.
London Office: 14, Leadenhall Street, E.C.
*See Illustrated Advt. in alternate issues.* Od 3391

**Dredging Plant**
OF ALL DESCRIPTIONS.
FLOATING CRANES. COAL BUNKERING VESSELS. 4030
**Werf Conrad,** HAARLEM, HOLLAND.
Agents: MARINE WORKS, LTD., FRIARS HOUSE, 39-41, NEW BROAD ST., LONDON, E.C.
*See half-page Advertisement, last and next week.*

**Mechanics and Metals**
**National Bank**
OF THE CITY OF NEW YORK.
ESTABLISHED 1810.
CAPITAL (Fully Paid) - - - $6,000,000
SURPLUS & UNDIVIDED PROFITS $9,000,000
This Bank receives Accounts of Banks, Bankers, Corporations, Firms and Individuals on favourable terms, and grants to its depositors every facility consistent with prudent and conservative banking methods.
CORRESPONDENCE INVITED.
FOREIGN DEPARTMENT.
Finances Exports and Imports, Buys and Sells Foreign Exchange, Telegraphic Transfers, &c., and makes Collections on all parts of the world.
LONDON BANKERS. 4778
LONDON JOINT STOCK BANK, LTD.
LONDON, CITY & MIDLAND BANK, LTD.

**Royles Limited,**
ENGINEERS, IRLAM, MANCHESTER.
FEED WATER HEATERS,
CALORIFIERS, EVAPORATORS, CONDENSERS, AIR HEATERS, STEAM AND GAS KETTLES. } Row's Patents.
Merrill's Patent TWIN STRAINERS for Pump Suctions
SYPHONIA STEAM TRAPS. REDUCING VALVES.
High-class GUNMETAL STEAM FITTINGS.
WATER SOFTENING and FILTERING. 4024

**Yarrow Patent**
**Water-Tube Boilers.** 4026
MESSRS. YARROW & CO., UNDERTAKE the PRESSING and MACHINING of the various parts of Yarrow Boilers, such as the Steam Drums, Water Pockets, and Superheaters for British and Foreign Firms not having the necessary facilities.
YARROW & CO., LTD., SCOTSTOUN, GLASGOW.

RAILWAY CARRIAGES, ELECTRIC CARS, &c.
**Hurst, Nelson & Co., Ltd.**
THE GLASGOW ROLLING STOCK AND PLANT WORKS, MOTHERWELL. Od 3393

**Taylor & Challen, Ltd.,**
BIRMINGHAM. 5196
**Presses for Sheet Metal**
PRODUCTS.
See Advertisement, April 7, page 47.

**Matthew Paul & Co., Ltd.**
LEVENFORD WORKS, **Dumbarton.** 4535
See Full Page Advt. page 48, April 7.

**Head, Wrightson & Co.,**
LIMITED.
—
See Advertisement page 29, April 14. 2402

**Coke, Gas and Oil Fired**
FURNACES. 4560
MONOMETER MANUFACTURING CO., LTD., WHITEHOUSE ST., ASTON, BIRMINGHAM.
See Advert. page 48, April 14.

**Wheel Lathes, New, Several**
Double-ended, Double-geared; height of centres from 18-22½ in., distance between centres 6-7 ft., chuck diameters 26-44 in.
GOODCHILD & MACNAB,
56, Eagle Street, London, W.C. D 609

**Repetition Machining Work.**
—FIRMS able to accept Contracts PLEASE COMMUNICATE with E 48, Offices of ENGINEERING.

**Punch and Shear Machine**
SPECIALISTS. 4784
Consult us. "The Best and the Cheapest." Large Stock. Satisfaction Guaranteed. Established 1860.
SCOTT BROS., WEST MOUNT, HALIFAX.

CHANTIERS & ATELIERS
**Augustin-Normand**
67, rue de Parrey—LE HAVRE (France). 3920
Destroyers, Torpedo Boats, Yachts and Fast Boats. Submarine and Submersible Boats.
NORMAND'S Patent Water-tube Boilers, Coal or Oil Heating. Diesel Oil Engines.

**Rubber** MANUFACTURERS
**Packings** "Redstone" "Bluestone"
GUTTA PERCHA & RUBBER, LIMITED,
Toronto - - Canada. 3211

**Centrifugals.**
—
**Pott, Cassels & Williamson,**
MOTHERWELL, SCOTLAND.
— 4781
See half-page Advertisement page 66, April 21.

**The Manchester Steam Users' ASSOCIATION.**

For the Prevention of Steam Boiler Explosions and for the Attainment of Economy in the Application of Steam.

9, MOUNT STREET, MANCHESTER.

Chief Engineer: C. E. STROMEYER, M.I.C.E.

Founded 1854 by Sir W. FAIRBAIRN.

Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 5169

PATENTS AND DESIGNS ACT, 1907.

**Notice is Hereby Given that** JAMES JONES, of 34, Thingwall Road, Wavertree, Liverpool, and A. McCONWELL & CO., LTD., of 60, Drury Buildings, Liverpool, seek leave to amend the Specification of Letters Patent No. 29657, of 1912, granted to James Jones for "Improvements in Metal Fire-bridges for the Furnaces of Steam Generators."

Particulars of the proposed Amendment were set forth in the *Illustrated Official Journal (Patents)*, issued on the 19th April, 1916.

Any person, or persons, may give notice of Opposition to the Amendment by leaving Patents Form No. 18, at the Patent Office, 25, Southampton Buildings, London, W.C., within one calendar month from the date of the said Journal.

W. TEMPLE FRANKS,
Comptroller-General.

Address for Service:—W. P. THOMPSON & Co., Chartered Patent Agents, 6, Lord Street, Liverpool. E 101

**Women's Employment.** — Special Course for Women in ENGINEERING TRACING, Tuesday and Thursday evenings, commencing on Tuesday, 2nd May, at 7.30. Fee for the course 10s. — Particulars of the SECRETARY, BATTERSEA POLYTECHNIC, S.W. E 41

**A National Need.**

BRITISH SCHOOL OF AERONAUTICS.

Aeroplanes and Airships. Construction, Design and Draughtsmanship. Complete Postal Courses. Also preparation for Exams. of Institutions of Civil, Mechanical and Electrical Engineers. — PENNINGTONS, 254, Oxford Road, Manchester. 4337


## TENDERS.

THE METROPOLITAN BOROUGH OF HAMMERSMITH.
The Borough Council

**Require a Press for Baling** Waste Paper. The Machine, the framework of which may be of wood or iron, must be capable of turning out bales weighing approximately 4 cwt. Price, full particulars, sketch of machine, with size of main parts figured thereon, to be delivered to me not later than Twelve Noon on Friday, the 5th proximo, endorsed "Tender for Baling Machine."

LESLIE GORDON,
Town Clerk.

Town Hall, Hammersmith, W.,
20th April, 1916. E 125

## APPOINTMENTS OPEN.

**Large Midland Manufacturing** Firm REQUIRE SERVICES of GENTLEMAN with first-class experience to assist head of commercial side of business, including direction of estimating and correspondence departments. Must be competent dictator, with capacity for handling extensive correspondence on own initiative. Reply should furnish full particulars, approximate views as to salary, and testimonials (copies only).—BOX 409, SMITH'S AGENCY, Ltd., 100, Fleet Street, E.C. E 78

**Works Manager Required, to** take responsible charge of boiler works, engine shops, smithies and foundries of large Midland Firm normally manufacturing portable steam engines, steam wagons and traction engines, but now employed on Government work of various kinds. 1300 men are engaged in the departments mentioned.

APPLICATION for Candidates who have had direct experience on the class of work named, or who have held a similar position in a first-class locomotive works will receive special consideration.

All communications will be treated confidentially, and replies should give full particulars of age, actual experience, and present employment.

Address, E 40, Offices of ENGINEERING.

**Works Superintendent.—An** engineering firm employing 1400 hands (men and women) REQUIRES the immediate SERVICES of a fully-trained ENGINEER to take charge of the machine, fitting and erecting shops. He must be a Six o'clock man, a good disciplinarian and organizer, possess initiative, executive ability, and have expert knowledge of machine tools for repetition work.

An attractive salary will be paid, and applications only considered from those who can show successful experience in a similar post.

Address, E 75, Offices of ENGINEERING.

**Refrigerating Engineers** WANTED, for cold stores.—Apply, by letter, stating age, if married, and give details of experience and salary expected, to BOX 677, J. B. BROWN'S Advertising Offices, 163, Queen Victoria Street, E.C. E 110

LONDON COUNTY ASYLUM, CANE HILL, COULSDON, SURREY.

**Working Foreman Engineer** REQUIRED, temporarily, for the period of the War, to take charge, under the Asylums Engineer, of the whole of the engineering appliances, which include the heating and hot water systems, deep well pumping plant, gas mains, laundry machinery, cooking apparatus and high and low pressure boilers, and minor electrical appliances.

Applicants must be thorough mechanics, and experienced in the control of men. Salary at the rate of £150 a year, and a house, or an allowance of £25 a year in lieu. Candidates must be ineligible for military service.

Applications (in writing), which should state fully the Candidate's experience and qualifications, age, &c., and be accompanied by copies of not more than three recent testimonials, to be forwarded at once to the undersigned.

H. F. KEENE,
Clerk of the Asylums and Mental Deficiency Committee, L.C.C.

2, Savoy Hill,
Victoria Embankment, W.C.
22nd April, 1916. E 106

**French Engineer Required,** for translating engineering catalogues into French.—Apply, STANDARD CATALOGUE PUBLISHING CO., LTD., 26, Hart St., Bloomsbury, W.C. E 112

**Young Engineer, accustomed** to works hours, WANTED, to assist chemical works manager. Must be well grounded in constructional engineering and building, and not eligible for military service, nor now employed on Government work. Good prospects for suitable man.—Address, stating age, experience, qualifications, and wages required, E 99, Offices of ENGINEERING.

**Vacancy for a Temporary** ASSISTANT METALLURGIST, with experience in metallurgical analysis. Candidates should be University graduates. Salary £150 per annum.—Applications, with copies of testimonials, to be forwarded to the SUPERINTENDENT OF RESEARCH, Royal Arsenal, Woolwich. E 96

**Wanted, a Thoroughly Com-** petent CHIEF DRAUGHTSMAN, for small engineering works in South Wales. No person already employed on Government work will be engaged.—Apply, with full particulars of previous experience, salary required, &c., to nearest LABOUR EXCHANGE, mentioning this Journal and E 116.

**Wanted, Draughtsman** (architectural or civil engineering). Ineligible for military service.

State particulars to the CIVIL ENGINEER,
R.N. Camp,
Blandford, E 80
Dorset.

**One or Two First-class** DRAUGHTSMEN REQUIRED, preferably with experience of hydraulic plant and steel works machinery. No person already employed on Government work will be engaged. State experience, age, salary required, and when at liberty.—Apply to the nearest BOARD OF TRADE LABOUR EXCHANGE, mentioning this Journal, and D 512.

**Wanted, Jig and Tool** DRAUGHTSMEN, for magneto work, in large Controlled Establishment, London district. Previous experience desirable, but not essential. Those already engaged on Government work need not apply.—Apply your nearest LABOUR EXCHANGE, mentioning this paper and No. B 5. E 11

**Draughtsmen, Jig and Tool,** REQUIRED immediately, for Government work. Must be conversant with modern workshop practice. Good wages and prospects. No man on Government work need apply.—Write, or apply, your nearest BOARD OF TRADE LABOUR EXCHANGE, mentioning this paper and No. A 1739. E 100

**Wanted, for Westminster,** one or two good Crane DRAUGHTSMEN, used to steam or electric cranes, and preferably accustomed to steel works practice. No person already employed on Government work will be engaged.—Apply, nearest LABOUR EXCHANGE, mentioning this Journal and E 114.

**Experienced Electrical** DRAUGHTSMAN WANTED. Those used to H.-T. detail work preferred. No person already employed on Government work will be engaged.—Apply, giving full particulars and salary required, to nearest LABOUR EXCHANGE, mentioning this Journal and E 33.

**For Manchester District.—** JUNIOR DRAUGHTSMAN WANTED, for reinforced concrete work. Must be capable of calculations. Previous experience necessary. Also must be exempt from military service. State age, wage, experience, &c.—Address, E 98, Offices of ENGINEERING.

**Wanted, Foreman, for** magneto work, in large Controlled Establishment, London district. Permanent position for good man. Wages according to ability and experience. Those already engaged on Government work need not apply.—Apply your nearest LABOUR EXCHANGE, mentioning this paper and No. B 3. E 9

**Wanted, a Capable Foreman,** to take charge of the running side of large water-tube boiler plant. Experienced men only need apply. Give particulars of experience, age and wages required. No man already engaged on Government work need apply.—Communicate with your nearest BOARD OF TRADE LABOUR EXCHANGE, mentioning this Journal and E 91.

**Wanted, Foreman Turner,** for centrifugal pump details. Must have good knowledge of up-to-date and rapid production methods. State experience, age and wage required. No person on Government work will be engaged.—Apply, your nearest LABOUR EXCHANGE, quoting No. A 1730. E 67

**Wanted, Assistant Machine** Shop FOREMAN, in Controlled Establishment doing Admiralty work only, about 120 machines, turning out small high class engines. Must have thorough experience and good control of men. Permanent situation for suitable man. District, Eastern Counties. State experience, age, and wages required. No person already employed on Government work will be engaged.—Apply, nearest LABOUR EXCHANGE, mentioning this Journal and E 37.

**Rate Fixer, for large general** engineering works. Must have some knowledge of up-to-date methods, jigs and machine tools. State experience, age and wage required. No person on Government work will be engaged.—Apply, your nearest LABOUR EXCHANGE, quoting No. A 1721. E 68

**Wanted, for Government** work, Controlled Establishment, London district, INSTRUMENT MAKERS, CLOCK MAKERS, DIE SINKERS, MAGNETO REPAIRERS, and any men used to accurate work. Those already engaged on Government work need not apply.—Apply your nearest LABOUR EXCHANGE, mentioning this paper and No. B 1. E 8

**West Africa.—Storekeeper** REQUIRED (ineligible), with experience in engineer's ship stores or hardware preferred.—Write, stating age, qualifications, and salary required, to BOX N 101, LEE & NIGHTINGALE, Liverpool. E 105

**Munition Factory Requires** several JIG and TOOL MAKERS, also INSTRUMENT MAKERS and TURNERS, willing to learn to Operate and Set-up Cleveland, Gridley, and Brown and Sharpe automatic machines. No person already engaged on Government work will be considered.—Apply, in first case, to the nearest LABOUR EXCHANGE, mentioning this Journal and C 870.

**Wanted, Toolmakers used to** jig work, TOOL TURNERS, and JIG MAKERS, for Government work, in Controlled Establishment, London district. Good wages and permanent position to suitable men. Those already engaged on Government work need not apply.—Apply your nearest LABOUR EXCHANGE, mentioning this paper and No. B 4. E 10

**Wanted, by Lancashire Firm,** Several First-class TURNERS, to start up new plant for 4.5 shells. Good wages and bonus to suitable men. No person already employed on Government work will be engaged.—Apply to nearest LABOUR EXCHANGE, mentioning this Journal and E 1.

**Engineering Pupil.—Vacancy** with Firm (Government Contractors) manufacturing latest types of machinery, oil and gas engines, &c.; moderate premium.—Address, 6521, Offices of ENGINEERING.

**Pupil. — The Borough and** Waterworks Engineer (A.M.I.C.E.), of Leamington, has a VACANCY in his office for a PUPIL.—Address, TOWN HALL. C 342

**A Large Firm of Engineers,** in the Midlands, have an OPENING for a YOUTH of good education as premium pupil, the course to include both works and drawing office.—Address, 4359, Offices of ENGINEERING.

## SITUATIONS WANTED.

**Engineer, M.I. Mech. E., Open** to UNDERTAKE designing, inspections and tests; wide knowledge mechanical, electrical and pneumatic engineering; also French, Russian and Spanish languages.—E 52, Offices of ENGINEERING.

**Mechanical and Electrical** Engineer (31), ineligible for the army, having had exceptional commercial experience, SEEKS responsible POSITION, preferably Lancashire district. At liberty any time. Large remuneration not essential if with good prospects.—E 43, Offices of ENGINEERING.

**Engineer, A.M.I. Mech. E.,** 28 years' works and office experience, rolling mills, testing machines, inspection buildings, automatic machines, electrical plant, boilers, &c.—Address, E 97, Offices of ENGINEERING.

**Engineer, 25 years' varied** experience, including the installation and upkeep of factory plant, SEEKS POSITION as Works Engineer, or other responsible position. London area.—Address, E 109, Offices of ENGINEERING.

**Commercial Engineer (English-** man), (40), over 10 years manager important engineering business on the Continent, handling large contracts, DESIRES CHANGE. Fluent French, Spanish, Portuguese, some knowledge Italian and Russian. Sound and successful business organiser. Tactful negotiator, with good address. Highest references. Open to accept really well-paid, responsible position with high-class engineering firm. Personal interview can be arranged London.—Address, C. E. G., at HORNCASTLE'S, 61, Cheapside, E.C. E 122

**Experienced Draughtsman** (32) DESIRES responsible POSITION, preferably on War work. Marine (Admiralty and passenger), details and arrangements, pumping machinery, Corliss and drop-valve engines, turbo details and layouts, condensing plants. Shop-trained man. Good references.—Address, E 106, Offices of ENGINEERING.

## PARTNERSHIPS.

**Every Engineer** desiring a **Partner** or a **Partnership** should write fully to WHEATLEY KIRK, PRICE & CO., 46, Watling Street, LONDON, E.C., Albert Square, Manchester, or 4004 26, Collingwood Street, Newcastle-on-Tyne.

**Mechanical Engineer Wants** PARTNERSHIP in a well-established concern in or near London. Wide experience and capital up to £4500. Business must show good past profits and be open to investigation.—Apply, WHEATLEY KIRK, PRICE & CO., 46, Watling Street, London, E.C. E 115

**Partnership.—£4000.—** WANTED, a Semi-sleeping PARTNER, engineering and contracting business, provincial, established over 26 years, with large and influential connections. Also Consulting Engineers and Valuers business in London (suspended for duration of War). Incoming partner will have option to nominate a junior partner to learn the business. Present partners on active military service. Assets £8000. No payment for goodwill. Further particulars at interview.—Address letters to WARD PERKS & TERRY, Solicitors, 85, Gracechurch Street, E.C. E 113

## PATENT AGENTS.

**The Consulting Patent** AGENCY, 253, Gray's Inn Road, London. Regd. British, U.S.A., and Canadian Agents. "Cepators, London" — Holborn 6109. All matters at fixed inclusive charges. 4445

**Jensen and Son,** 4384 CHARTERED PATENT AGENTS, (Established 1867). British, Colonial, and Foreign Patents, and Trade Marks and Designs Registrations, 77, Chancery Lane, London, W.C. Tel.: Holborn 1248.

**John E. Raworth,** CHARTERED PATENT AGENT, 70/71, Queen Anne's Chambers, 4995 Tothill Street, Westminster, S.W.

## AUCTION SALES.

**Wheatley Kirk, Price & Co.** (Established 1850.)

**Auctioneers** AND VALUERS OF 4004

ENGINEERING WORKS PLANT AND STOCK,

46, WATLING STREET, LONDON, E.C.

16, ALBERT SQ., MANCHESTER. 26, COLLINGWOOD ST., NEWCASTLE-ON-TYNE.

Telephones & Telegrams at each Address.

SECOND DAY'S SALE.

STATION YARD, HAYWARDS HEATH.

IMPORTANT SALE of about 550 LOTS OF MACHINERY, IRONMONGERY, CONTENTS of BLACKSMITH'S SHOP and Miscellaneous Effects, comprising Two Drilling Machines, Iron Shearing Machine, Two Gas Engines, One Oil ditto, Screw-cutting Lathe, 6-ft. bed, with Overhead Motion, 10-ft. Engine Boiler, Turning Lathe (13-ft. bed), Shafting and Pulleys, Three Treadle Lathes, Horse-shoe Bending Machine and Nail-hole Stamping ditto, about 30 Tons of Bar Steel and Iron, quantity Steel Tubing, Bolt-making Machine, Sheet Iron, Chain, Blacksmith's Forges, Bellows, Iron Vices, Anvils and Miscellaneous Blacksmith's Tools, 16 pairs 42-in. Wheels, with Axles, Pulley Wheels, Nine Platform Weighing Machines, by "Day and Milward," to weigh 1200 lbs., Treadle Band Saw, Levelling Plate, 4 ft. by 2 ft., Steel, Wrought and Cast-iron Scrap, and a Large Assortment of other Effects, which

**Messrs. T. Bannister & Co.** will SELL by AUCTION, upon the Premises as above,

On FRIDAY, MAY 12th, 1916,

By order of Mr. A. W. KNIGHT, who is quitting these premises. E 118

Sale to commence at 10.30 a.m.

On view two previous days and morning of sale.

Catalogues may be obtained of the AUCTIONEERS, Market Place, Haywards Heath. (Tel. No. 7).

**Knight & Partners,**

Engineers, Auctioneers and Valuers,

have received instructions to

DISPOSE

of a Miscellaneous

QUANTITY of MACHINE TOOLS,

and beg to announce that the same will be

SOLD by AUCTION,

at their Sale Rooms, at an

EARLY DATE.

Further Entries of Machinery, &c., will be accepted, if notice is given, not later than MAY 6th.

Full particulars of the AUCTIONEERS at their Offices—

31, Old Queen Street,
Westminster, S.W. E 59

## WANTED, &c.

TO MUNITION FIRMS.

**Firm of Contractors have** available for immediate use, owing to the abandonment of a large road-making contract in the South of England, several miles of RAILWAY (24 in. gauge), WAGONS and LOCOMOTIVE, all Tools and Appliances to undertake laying out of sites, drainage, main laying, railway or waterworks of any magnitude. Managing staff, in addition to foremen and leading men ineligible for military service, also available. South or Midland districts preferred.

G. PERCY TRENTHAM LIMITED,
Contractors,
Victoria Square, Birmingham.
Tels. Address: "Pertren, Birmingham." E 30

**Tracings and Photo-copies** Accurately and Promptly EXECUTED by A. WEST & PARTNERS, (Official Contractors to the Admiralty), 91, York Street, Westminster.

**Italy.—Engineer,** well introduced, returning to Italy in July, WOULD LIKE to NEGOTIATE for representation. Residence at Milan centre of industry. Long travelling experience British firms all over the Continent.—Address, E 103, Offices of ENGINEERING.

**South America. — Firm of** thoroughly sound AGENTS REQUIRED, for the Argentine, Brazil, &c., to take over the representation of a new system of gas producers with and without by-product recovery.—Write, Z. W. 998, care of DEACON'S, Leadenhall Street, E.C. E 108

**Designer of New Breech** Block for big guns, 12 in. upwards, WISHES to HEAR from British or American FIRMS interested in such.—Write, BOX A 648, care of DAWSON'S, 121, Cannon Street, London, E.C. E 66

**Engineering Firm (London** Suburbs), on completion of important Munitions Contract, will shortly have quantity of spare plant available, and SOLICITS ENQUIRIES for the Manufacturing of High-class Engineering Specialities.—Address, E 104, Offices of ENGINEERING.

# THE RUNNING OF BOILER PLANTS AND NATIONAL ECONOMY.

By D. BROWNLIE, B.Sc. Hons. (Lond.), F.C.S., and H. GREEN.

(*Concluded from page* 342.)

## DETAILED ANALYSIS OF THE RESULTS OF THE HUNDRED TESTS.

1. *Analysis of Fuel Used.*—In only three cases was the coal analysed in an accurate manner and purchased scientifically, guided by the determination of the heating value. In certainly over ninety cases the coal was purchased in a general rule-of-thumb manner, without any accurate knowledge of its real value. It is perhaps hardly necessary to point out that a firm who buys coal buys heat; that, other things being equal, the coal that contains the most heat is the best value for the money, and that it is impossible to get the best results by buying and using coal completely in the dark as to its heating value. In our opinion there is certainly not 5 per cent. of steam-users who buy their coal on scientific lines.

It would hardly be possible to give a better example of the general lack of scientific methods in vogue than that of the buying and selling of coal. As shown later, we estimate the value of the coal consumed for steam-raising purposes in Great Britain as approximately 17,000,000*l.* per annum. Of this total probably at least 16,000,000*l.* worth is purchased by methods which would be ridiculed in nearly every other form of buying and selling. Our own experience is that the average firm can save 7 to 10 per cent. of the coal bill alone by buying on scientific lines—that is, by buying the coal which is the best value under the conditions of the given steam-generating plant.

2. *Quality of Coal.*—The average for the hundred plants shows 12,680 B.Th.U. and 9.3 per cent. ash. Among the best coals in use we found washed acorns giving an average heating value of 14,200 B.Th.U. and 2.5 per cent. ash, and many rough or burgy coals showed over 13,500 B.Th.U. A good washed slack or peas averages about 13,000 B.Th.U. to 13,750 B.Th.U., with, say, 4 to 7 per cent. ash. Among the worst samples are small slacks of about 11,500 B.Th.U. and 18 to 20 per cent. ash, whilst refuse coal, such as washer settlings, may be as low as 7000 B.Th.U.

3. *Method of Firing.*—In sixty-one cases hand-firing was in use as against thirty-nine cases with mechanical firing, representing seven different makes of mechanical stokers, of which a total of twenty-seven were of the sprinkling type and twelve of the coking type. The following were the comparative results:—

*Comparison of Hand and Mechanical Firing.*

| — | Average of 100 Tests, Complete. | Typical Boiler Plant Run on Scientific Lines. | Average of 61 Cases, Hand-Firing. | Average of 39 Cases, Mechanical-Stoker Firing. |
|---|---|---|---|---|
| Duration of trial .. hours | 10.66 | 6.75 | 11.02 | 10.09 |
| Amount of coal used .. lb. | 26,994 | 28,200 | 25,999 | 28,550 |
| Price of coal used .. .. | 12s. 2d. | 15s. | 12s. | 12s. 5d. |
| Analysis of coal used:— | | | | |
| B.Th.U. .. .. .. | 12,680 | 11,980 | 12,706 | 12,639 |
| Ash .. .. per cent. | 9.3 | 12.5 | 9.28 | 9.33 |
| Coal burnt per boiler per hour .. .. .. lb. | 791.3 | 1044.4 | 673.3 | 972.6 |
| Water evaporated .. lb. | 192,630 | 224,050 | 195,788 | 187,945 |
| deg. F. | (117) | (95) | (118.7) | (114.3) |
| Water evaporated per boiler per hour .. .. lb. | 5648.9 | 8298.0 | 5122.1 | 6467.7 |
| Water evaporated per pound of coal .. .. .. lb. | 7.13 | 7.94 | 7.52 | 6.58 |
| Water from and at 212 deg. F. evaporated per pound of coal .. .. .. lb. | 8.11 | 9.21 | 8.54 | 7.43 |
| Temperature of feed-water before economisers, deg. F. | 117 | 95 | 118.7 | 114.3 |
| Temperature of feed-water after economisers deg. F. | 226 | 305 | 224.6 | 228.2 |
| Saving due to economisers per cent. | 10.1 | 13.5 | 9.8 | 10.6 |
| $CO_2$ .. .. per cent. | 7.5 | 12.0 | 7.7 | 7.2 |
| Steam-pressure (gauge) lb. | 93.5 | 159.0 | 89.0 | 100.5 |
| Temperature of steam, deg. F. | 333.2 | 370.0 | 330.5 | 337.9 |
| Temperature of superheat deg. F. | 369.6 | 540.0 | 363.1 | 379.7 |
| Steam used as auxiliary, per cent. .. .. .. .. | 1.5 | 3.5 | 0.54 | 3.0 |
| Efficiency:— | | | | |
| A. Plant complete, including auxiliary steam per cent. | 62.05 | 78.68 | 65.76 | 56.19 |
| B. Boilers only ,, | 55.65 | 60.99 | 58.62 | 51.0 |
| C. Superheat only ,, | 1.08 | 6.39 | 1.12 | 1.02 |
| D. Economisers only ,, | 6.24 | 14.16 | 6.38 | 6.02 |
| Cost in coal to evaporate 1000 gallons of water .. .. | 91.2d. | 100.9d. | 85.3d. | 100.6d. |

There is a very violent conflict of opinion among steam-users as to the advantages or otherwise of mechanical stoking as compared with hand-firing. As seen from the figures, we find that 61 cases of hand-firing are giving better results than 39 cases of mechanical firing.

It will be noted that the figures happen to give a particularly fair comparison, as the qualities of the coal, the temperature of the feed-water, the rise in temperature due to the economisers, and the amount of superheat are almost identical. There is a difference of 9.57 per cent. in efficiency against mechanical stoking, which is a very big item, particularly when it is remembered that this does not include the cost of upkeep. Except under proper supervision this latter is apt to be very high, often as much as 25*l.*, or even 30*l.*, per boiler per annum. As against this, on a fairly large plant, the cost of labour is less with mechanical firing. We are so used to reading the remarkable results of boiler trials in the catalogues of some mechanical-stoker firms, that an average efficiency of 56 per cent. under actual working conditions comes somewhat as a shock.

Taking boiler plants generally, there is, however, probably little real difference as regards efficiency, or rather lack of efficiency, between hand and mechanical firing. Obviously a great many factors enter into the case, such as quality of fuel to be burnt, amount of steam required, and whether the demand is fluctuating or not, the quality of the supervision in both cases, and so on. Most mechanical stokers work well under certain conditions, and as both hand-fired and mechanically-fired plants receive very little scientific attention and supervision, the whole question has resolved itself into opinions backed up by very little real information.

One can only say that with both hand and mechanical firing 80 to 85 per cent. efficiency can be maintained, and a very careful examination of the general working conditions of the plant must be made before deciding for hand or mechanical firing, and if the latter, which type of stoker. We may say, further, that in the case of the 61 plants with hand-firing, 51 plants were fitted with the ordinary Lancashire fire-bars, and 10 were some form of patent bar, mostly a hollow bar fitted with steam-jets. Generally these give no better results than the ordinary Lancashire fire-bar.

4. *Measurement of Feed-Water.*—Out of the 100 plants, in seven cases only was there any apparatus installed on the plant for determining regularly the water evaporated—that is, the amount of the steam produced. Further, out of the seven cases, several of the water-meters in use were certainly not accurate. A boiler plant is, of course, a little factory in itself, in which the finished product is steam, and unless there is some form of water-measuring apparatus at work to regularly check the performance of the plant, there is bound to be some loss. How much is merely a matter of accident. We should say that not 5 per cent. of the boiler plants of the country are fitted with water-measuring apparatus in regular use. Further, we may say that a very large proportion of the apparatus actually in use is not giving accurate results, partly due to lack of attention and partly due to inherent defects in the apparatus.

5. *Amount of Water Evaporated.*—The average figures for the 100 tests show approximately an evaporation of 565 gallons per boiler per hour, with Lancashire boilers of an average size of 30 ft. by 8 ft. These figures refer to the average evaporation per working day, and not, of course, to the evaporation of any particular hour.

Although the evaporation of a boiler largely depends on the quality of the coal used, speaking generally, it would be possible for the boiler plants of the country to evaporate much more water per boiler per hour. There are hundreds of plants at work which are always more or less short of steam, and in which, by a very moderate amount of re-organisation, the output of steam could be considerably increased, making a great difference in the efficiency of the general running of the factory. Thus, in the typical example of a well-managed plant, the figure is approximately 830 gallons per boiler per hour, which is an increase in evaporation of over 45 per cent. over the average.

6. *Feed-Water Examination.*—With regard to scale troubles, out of the 100 plants 34 either had no trouble at all or only very slight, 45 were what might be described as "usual" or "medium," whilst five cases could only be described as "chronic." With regard to the methods in use for coping with these difficulties, in 69 cases there was no treatment at all (34 cases where no treatment was required and 35 cases where the scale was simply allowed to form, and was then chipped off again). In 14 cases a water-softening plant was in use, and in 17 cases some form of boiler composition was being added to the boiler feed-water.

In the case of water-softening plants, out of the 14 cases in only 6 cases was the softening plant being worked properly and controlled by regular daily analysis. In one or two cases the water was no better, or even worse as regards the presence of scale-forming elements, after passing through the water-softening plants, due, of course, to wrong proportions of chemicals being used.

We should say that, if anything, these figures are better than the average for the whole country. In certainly well over 50 per cent. of cases where a water-softening plant is installed the proper attention and daily analysis are carried out for a few weeks, and then very soon the plant is left to work by itself, a change of chemicals being added every day merely as a matter of habit, without the least attention being paid to the results, and the variation in the quality of the water.

With regard to boiler compositions, in addition to the 17 cases mentioned, we have analysed many other samples of boiler compositions. In most cases we have found these compositions to consist simply of caustic or soda ash, or mixtures of these, together with some vegetable product, very often a crude form of tannic acid. Some of these compositions can only be described as extraordinary. Thus one of them had 95 per cent. water, 0.5 per cent. soda ash, and 4.5 per cent. tan-yard refuse. If, however, they vary in composition, they seem to show a great similarity from the point of view of exorbitance in price and failure to prevent scale. Most of their "good" effects are due to the caustic soda, and if it is desired to put caustic soda into the boilers (which is not to be recommended), this can be purchased at about one-tenth of the price.

As regards corrosion, we found only two or three cases in the hundred—one due to "peaty" acid in moorland water, and the others to mineral acid in the river from the effluent of some other works.

7. *Economisers.*—Out of the 100 plants tested, 87 plants were fitted with economisers, the other 13 plants having no means whatever of utilising the waste heat from the boiler-flues. In several of these latter cases the economisers had been worn out and never replaced. In the figures for the average of 100 tests, the saving due to the economisers is 10.1 per cent., which includes, of course, 13 plants not fitted with economisers. Taking the 87 plants fitted with economisers, the average saving is 11.6 per cent. of the coal bill. We should say that this is a fair average for the whole country. The highest figure we found was 19 per cent. on a cotton-mill plant.

The makers of economisers generally state that 15 to 25 per cent. of the coal can be saved by installing economisers, meaning, we presume, after the boiler has received its proper proportion of heat and the efficiency of the boiler only is as high as it should be. It is naturally quite easy to increase the "saving" due to the economisers; for example, by running an induced-draught fan at high speed and reducing the efficiency of the boilers. We have generally found that results showing over 17½ per cent. saving due to the economisers are caused in this way, and the figure is therefore not a real saving in the scientific sense of the word. Whether it is possible to get 25 per cent. real saving is a matter of opinion.

In almost every case economisers are installed in the most rule-of-thumb manner, the general practice being to allow either 72 or 96 tubes for each boiler, quite regardless of the evaporation of the boilers. The economiser-makers generally recommend sufficient tubes to hold about an hour's supply of feed water, reckoning the capacity of each 9-ft. tube as 6½ lb. When it is remembered that a 30-ft. by 8-ft. Lancashire boiler may be evaporating on an average anything from 300 to 1000 gallons per hour, and economisers are almost always installed without knowing anything of the evaporation of the plant, it will be obvious that the economiser does not get a fair chance to show its maximum efficiency. Also in a large number of cases they receive practically no attention, are allowed to "scale up" inside, and in some cases even the scrapers are not working.

8. *Method of Draught.*—Out of the 100 plants, 53 were working with chimney draught only,

32 with some form of steam-jet apparatus to assist the chimney draught, 13 with mechanical induced-draught fan, and two with mechanical forced-draught fan. The draught obtained in 53 cases by means of chimney only we found to average 0.79 in. suction-water gauge in the chimney base, giving 0.38 in. suction-water gauge in the side flues of the boiler. The highest water-gauge we found to be 1.6 in. in the chimney base. As regards temperature in the chimney base, the average for the 53 cases was 476 deg. Fahr., varying from the lowest at 293 deg. Fahr. to the highest at 785 deg. Fahr.

Comparing the 53 cases of chimney draught with the 13 cases of mechanical induced draught, we found that in the latter case the average suction in the fan inlet was 1.51 in., the highest being 3.1 in. and the lowest 0.4 in., water gauge, giving 0.62 in the side flues. Temperature in fan inlet, 420.5 deg.; highest, 665 deg.; lowest, 306 deg. Fahr. As a matter of interest, we give below the full figures for the performance of the 53 chimney-draught plants, compared with the 13 induced-draught plants :—

*Comparison of Natural Chimney Draught and Induced Draught.*

| — | Average of 100 Plants Complete. | Typical Boiler Plant, Run on Scientific Lines. | Average of 53 Cases of Chimney Draught only, No Steam Power Used as Auxiliary. | Average of 13 Cases of Induced Draught. |
|---|---|---|---|---|
| Duration of trial .. hours | 10.66 | 6.75 | 10.81 | 10.10 |
| Amount of coal used .. lb. | 26,994 | 28,200 | 27,527 | 24,056 |
| Price of coal used .. .. | 12s. 2d. | 15s. | 11s. 5d. | 12s. 5d. |
| Analysis of coal used :— | | | | |
| B.Th.U. .. .. .. | 12,680 | 11,980 | 12,831 | 12,513 |
| Ash .. .. per cent. | 9.3 | 12.5 | 8.8 | 9.9 |
| Coal burnt per boiler per hour .. .. .. lb. | 791.3 | 1044.4 | 755.6 | 1000.7 |
| Water evaporated .. .. deg. F. | 192,630 (117) | 224,050 (95) | 192,481 (113) | 160,100 (109) |
| Water evaporated per boiler per hour .. .. lb. | 5646.9 | 8296.0 | 5283.7 | 6660.3 |
| Water evaporated per pound of coal .. .. .. .. | 7.13 | 7.94 | 6.99 | 6.65 |
| Water from and at 212 deg. Fahr. evaporated per pound of coal .. .. .. .. | 8.11 | 9.21 | 7.96 | 7.66 |
| Temperature of feed-water before economisers deg. F. | 117 | 95 | 113 | 109 |
| Temperature of feed-water after economisers deg. F. | 226 | 305 | 210 | 264 |
| Saving due to economisers per cent. | 10.1 | 18.5 | 9.8 | 10.6 |
| $CO_2$ .. .. .. " | 7.5 | 12.0 | 7.27 | 6.8 |
| Steam pressure (gauge) lb. | 98.5 | 15.9 | 87.0 | 124 |
| Temperature of superheat deg. F. | 369.6 | 540.0 | 360.0 | 417.0 |
| Temperature of steam deg. F. | 333.2 | 370.0 | 329.1 | 352.3 |
| Steam used as auxiliary, per cent. .. .. .. .. | 1.5 | 3.5 | Nil | 2.75 |
| Efficiency : | | | | |
| A. Plant complete, including auxiliary steam per cent. | 62.03 | 78.68 | 61.02 | 59.58 |
| B. Boilers only " | 55.65 | 60.99 | 54.70 | 50.84 |
| C. Superheat only " | 1.08 | 6.39 | 0.94 | 2.03 |
| D. Economisers only " | 6.24 | 14.16 | 5.38 | 8.39 |
| Cost in coal to evaporate 1000 gallons of water .. .. | 91.9d. | 100.9d. | 87.4d. | 99.9d. |

There is also a very strong difference of opinion as to relative merits of natural and mechanical draught. As seen, we found that 53 cases of chimney draught were giving better results than 13 cases of induced draught. We should say that these figures are approximately correct for the whole of the plants of the country.

Our own opinion is that some form of artificial draught is essential to the highest efficiency, and by comparison with a properly-managed plant chimney draught is bound to give inferior results. Artificial draught is, however, more complicated, and if it is applied on wrong lines, or does not receive proper attention, it is easily possible to waste much more money than with chimney draught, and many of the most uneconomical plants in the country are working with artificial draught.

8. *Estimation of $CO_2$.*—Out of the 100 plants, 92 were not equipped with $CO_2$ recorders, four were equipped with recorders in fairly good running order, and four had been equipped, but the machines were out of order and permanently discontinued. What proportion of boiler plants in the whole country are equipped with $CO_2$ recorders we do not pretend to know, but it is certainly not very high. One striking fact is the very large number of boiler plants met with that have been fitted with $CO_2$ recorders, and been forced to discontinue using them because of their complicated character. We should say that the $CO_2$ recorder has caused more trouble than any other instrument or appliance used in the boiler-house.

In order to get economical results it is, of course, necessary to have some form of $CO_2$ recorder on a boiler plant, but it must be used with discretion. To get the best results it is essential to have a high percentage of $CO_2$, say between 12 and 16 per cent., but it does not at all follow that a high figure necessarily means high efficiency, makers statements notwithstanding.

The figures we obtained for $CO_2$ by installing our own $CO_2$ recorders were as follow :—

| | Per Cent. | |
|---|---|---|
| 1. Very good... ... | Over 12 ... | 2 |
| 2. Good ... ... | 10 to 12 ... | 13 |
| 3. Medium ... ... | 8 " 10 ... | 30 |
| 4. Poor ... ... | 5 " 8 ... | 45 |
| 5. Very bad ... ... | Under 5 ... | 10 |
| Total ... ... ... | | 100 |

That is, 55 per cent. of cases were below 8 per cent. The best record we found was 14 per cent. average, and the worst 3.5 per cent. average.

9. *Black Smoke.*—Out of the 100 plants the following were the particulars as regards black smoke :

| | |
|---|---|
| 1. Good, practically no smoke at all ... | 29 |
| 2. Fairly good... ... ... ... ... | 23 |
| 3. Medium ... ... ... ... ... | 27 |
| 4. Bad ... ... ... ... ... ... | 18 |
| 5. Chronic; almost continuous black smoke | 3 |
| Total ... ... ... | 100 |

Out of the 100 plants, 15 were fitted with some form of patent smoke-preventer. Most of these smoke-preventers consist of some arrangement for allowing air to pass up the back of the bars so as to add excess air to the smoke on the Bunsen-burner principle. In practice they only give the most moderate results, and the way to stop black smoke economically is obviously to consume it in the furnaces.

It is really quite a simple matter to prevent black smoke and to get increased economy at the same time. It should be noted that, although a highly efficient plant will in all cases be practically smokeless, it does not follow that a plant having bad black smoke is necessarily very inefficient. For example, a plant may be working very well in every respect, giving, say, 13 or 14 per cent. $CO_2$. A trifle less air going through the fires will result in smoke, and perhaps 16 per cent. $CO_2$; but when in this condition the plant would be very much more efficient than many other plants that are smokeless, due to a large excess of air passing through the fires.

10. *Boiler Pressure.*—Out of the 100 plants, all varieties of average working pressure were experienced from 12 lb. (blow-off 30 lb.) to 190 lb. (blow-off 200 lb.).

The plants were divided as follow :—

| | |
|---|---|
| 1. Under 60 lb. average working pressure | 17 |
| 2. Between 60 lb. and 80 lb. working pressure ... ... ... ... ... | 23 |
| 3. Between 80 lb. and 100 lb. working pressure ... ... ... ... ... | 25 |
| 4. Between 100 lb. and 120 lb. working pressure ... ... ... ... ... | 16 |
| 5. Between 120 lb. and 160 lb. working pressure ... ... ... ... ... | 16 |
| 6. Over 160 lb. working pressure ... ... | 3 |
| Total ... ... ... | 100 |

As most engineers are aware, the engines of the country are, on the whole, working at much too low a pressure from the point of view of economical utilisation of steam, and our results show 40 per cent. of boiler plants working at less than 80 lb. pressure.

11. *Fluctuations in the Demand for Steam.*—There is in many instances considerable fluctuation in the demand for steam, and in each case this was ascertained by reading the water-meter every half-hour, and making a correction for differences in the gauge-glass levels. Some industries, such as cotton or flour-mills, have a very steady demand for steam from hour to hour, whilst others, such as paper-mills, dye-works, calico-printers, bleachers, and brewers, have very violent fluctuations. The worst example we tested was 40 per cent. difference in hourly evaporation ; that is, in one hour the evaporation would be 600 gallons per boiler per hour, and the next hour 1000 gallons. In most cases such plants are running without sufficient margin of steam pressure for economical working.

12. *Superheaters.*—Out of the 100 plants, 21 plants were fitted with superheaters, which includes eight plants only partially fitted. Of the 13 plants completely fitted, the average temperature of steam was 346 deg. Fahr. before superheating, and 475 deg. Fahr. after, being 129 deg. of superheat. The highest temperature of superheated steam tested was 650 deg. Fahr. We are, of course, not able to say what is the number of plants in the country fitted with superheaters.

13. *Annual Coal Bill.*—In this respect the 100 plants were divided as follows :—

| | |
|---|---|
| 1. Under 1000*l.* per annum ... ... ... | 11 |
| 2. Between 1000*l.* and 2000*l.* ... ... ... | 29 |
| 3. Between 2000*l.* and 4000*l.* ... ... ... | 34 |
| 4. Between 4000*l.* and 7000*l.* ... ... ... | 16 |
| 5. Between 7000*l.* and 10,000*l.* ... ... | 6 |
| 6. Between 10,000*l.* and 20,000*l.* ... ... | 2 |
| 7. Over 20,000*l.* ... ... ... ... ... | 2 |
| | 100 |

These figures represent approximately the three years 1913, 1914, and 1915, and on the present (1915-1916) increased prices the figures would be higher. The total coal bill for the 100 plants is 375,000*l.* per annum (1913-1915). The average price of coal was, as seen, 12s. 2d. per ton delivered, and varying from the lowest price of 7s. 3d. per ton delivered to 31s. per ton delivered.

14. *Steam or Power Used as an Auxiliary to the Production of Power.*—As already seen, out of the 100 plants 47 were using steam or power as an auxiliary to the production of steam, 32 being steam jets under or over the bars, 13 as induced draught, and two as forced draught. Out of the whole 47 cases the average amount of steam was 5 per cent. of the production in the boilers. With regard to induced or forced-draught fans, the average is approximately 2½ to 3 per cent. of the production.

With steam jets the amount varies very considerably, being anything from 3 to 12 per cent. of the production. Where the jets are used as the sole means of obtaining a draught, as in some types of patent fire-bar and mechanical stokers, the amount is rarely under 5 per cent. and may be as high as 12 per cent. In the types of stokers using steam jets to cool the bars the amount is generally between 2 and 3 per cent. Very little attention has hitherto been given to this question of auxiliary power. We have had many cases where some form of mechanical stoker or fire-bar has been installed, and on investigation the amount of steam used under the bars has been equivalent to the cost of a complete new outfit every 12 months.

15. *Efficiency of Plant.*—As seen, the average net working efficiency of the plants is 62.03 per cent. ; that is to say, out of every 100 lb. of coal put into the fires, 62.03 lb. are being used to produce useful steam, the other 37.97 lb. being wasted. This efficiency is split up into 55.65 per cent. for the boilers only, 1.08 per cent. for the superheaters, and 6.42 per cent. for the economisers, which, after allowing for 1.5 per cent. used as auxiliary steam, gives the net working efficiency of 62.03 per cent.

Taking the whole 100 plants, the efficiencies were divided as follows :—

| | |
|---|---|
| 1. Over 80 per cent. ... ... ... ... | 2 |
| 2. 75 to 80 " ... ... ... ... | 7 |
| 3. 70 " 75 " ... ... ... ... | 8 |
| 4. 65 " 70 " ... ... ... ... | 17 |
| 5. 60 " 65 " ... ... ... ... | 14 |
| 6. 55 " 60 " ... ... ... ... | 29 |
| 7. 50 " 55 " ... ... ... ... | 14 |
| Less than 50 per cent. ... ... ... | 9 |
| Total ... ... ... .... | 100 |

It will be noted that 52 per cent. of the plants are working with an efficiency of less than 60 per cent., and that only 17 per cent. of the plants exceed 70 per cent. efficiency.

16. *Cost in Coal to Evaporate 1000 Gallons.*—This figure, of course, depends to a large extent on the cost of coal in the locality, and is therefore not of much interest in comparing boiler plants in different localities. The difference between the cost of coal in, for example, Staffordshire as against the cost of the same quality of coal in London is enormous. We have, however, given the figures as a matter of interest. It will be noted in the figures given for different industries that it is costing sixteen paper-mills 87.8d. to evaporate 1000 gallons of water with an efficiency of 76.65 per cent., and it is only costing nineteen dyeing, &c., works 79.3d. with an efficiency of 59.48 per cent.

### Summary of Results.

A boiler plant worked on modern lines will give a net working efficiency of 80 to 85 per cent., depending on conditions. As seen, the average of

Summary of Results of Trials of 100 Boiler Plants.

| — | Average of 100 Plants Complete. | Typical Plant Run on Scientific Lines. | Average of 14 Cotton Mills. | Average of 16 Woollen Mills. | Average of 16 Paper Mills. | Average of 19 Dyeing, Bleaching, and Calico-Printing Works. |
|---|---|---|---|---|---|---|
| Duration of trial .. .. .. hours | 10.66 | 6.75 | 11.48 | 10.68 | 11.35 | 9.59 |
| Amount of coal used .. .. .. lb. | 26,994 | 28,200 | 28,904 | 21,802 | 34,166 | 20,539 |
| Price of coal per ton .. .. .. .. | 12s. 2d. in fire-hole | 15s. in fire-hole | 11s. | 11s. 10s. | 14s. 2d. | 10s. 6d. in fire-hole |
| Analysis of coal used :— | | | | | | |
| B.Th.U. .. .. .. .. .. | 12,680 | 11,980 | 13,451 | 12,886 | 12,347 | 13,104 |
| Ash .. .. .. .. per cent. | 9.3 | 12.5 | 6.8 | 9.9 | 10.6 | 8 |
| Coal burnt per boiler per hour .. lb. | 791.3 | 1044.4 | — | — | — | — |
| Water evaporated .. .. .. ,, | 192,630 | 224,050 | 222,475 | 155,410 | 295,675 | 145,560 |
| deg. F. | (117) | (95) | (103) | (112) | (137) | (94) |
| Water evaporated per pound of coal lb. | 7.13 exact | 7.94 exact | 7.69 exact | 7.13 exact | 8.63 exact | 7.08 exact |
| Equivalent evaporation from and at 212 deg. Fahr. per pound of coal .. lb. | 8.11 | 9.21 | 8.91 | 8.14 | 9.66 | 8.19 |
| Temperature of feed-water before economisers .. .. .. .. deg. F. | 117 | 95 | 103 | 112 | 137 | 94 |
| Temperature of feed - water after economisers .. .. .. .. deg. F. | 226 | 305 | 254 | 218 | 268 | 244 |
| Coal bill saved by economisers per cent. | 10.1 | 18.5 | 13.3 | 9.7 | 12.3 | 13.6 |
| $CO_2$.. .. .. .. .. ,, | 7.5 | 12.0 | 7.26 | 7.25 | 8.25 | 7.12 |
| Steam pressure :— | | | | | | |
| Gauge.. .. .. .. .. lb. | 93.5 | 159 | 123.9 | 89.0 | 112.0 | 75.0 |
| Absolute .. .. .. .. ,, | 108.0 | 174 | 139.0 | 104.0 | 127.0 | 90.0 |
| Temperature of saturation of steam, deg. F. | 333.2 | 370 | 352.3 | 330.5 | 345.3 | 320.1 |
| Temperature of superheated steam ,, | 369.6 | 540 | 409.3 | 338.0 | 395.0 | 324.1 |
| Steam used as auxiliary .. per cent. | 1.5 per cent. of steam raised (5 per cent. in 30 cases out of 100) | 3.5 | 1.2 | 2.9 | 1.4 | 1.9 |
| Thermal Efficiency :— | | | | | | |
| A. Net working efficiency after deducting steam used as auxiliary per cent. | 62.03 | | .11 | 58.53 | 76.65 | 59.48 |
| B. Boilers only .. .. ,, | 55.65 | | 55.28 | 55.10 | 66.47 | 52.27 |
| C. Economisers only .. ,, | 6.24 | | 8.79 | 5.97 | 9.29 | 8.25 |
| D. Superheaters only .. ,, | 1.08 | | 1.89 | 0.24 | 1.98 | 0.11 |
| Cost in coal to evaporate 1000 gallons of water | 91.3d. (1 gallon = 10 lb.); 89.1d. (actual reading on water-meter at 117 deg. F.) | | 76.5d. | 88.9d. | 87.8d. | 79.3d. |

sixteen paper mills shows 77.74 per cent., and these could be improved. If the badly-managed plants in this industry are deducted, the figure will be about 80 per cent. efficiency. The typical example we give of a well-managed plant shows 78.68 per cent., and this could be increased, although it is working with inferior coal. It is naturally much easier to get a high efficiency with good-quality coal and low evaporation, as compared with low-grade coal and a high evaporation. We can say, on the average, however, that every boiler plant could be run on 80 per cent. efficiency, and we will take this figure as the basis for comparison.

The total coal bill on the 100 plants tested was 375,000*l.* per annum, or an average of 3750*l.* per plant per annum. Since the average efficiency is 62.03 per cent., and it is possible to get 80 per cent., it is obvious that the saving that can be obtained by running these plants on scientific lines is approximately 18 per cent., or, say, 67,500*l.* per annum. We are of the opinion that this figure is really better than the true average, and we think that the average efficiency of the boiler plants of this country is not higher than about 60 per cent., corresponding to 20 per cent. saving to be obtained. There are, of course, scores of plants at work where 50 per cent. could be saved. What this represents exactly as a national loss it is very difficult to say.

The amount of coal raised in the United Kingdom for the year 1914 was 265,664,394 tons, and in 1913 the figure was 287,411,869 tons. In 1907 the production of coal in Great Britain was 267,831,000 tons, valued at 120,530,000*l.* Of this, 182,643,000 tons was consumed in Great Britain, representing a value of 82,193,300*l.* It is impossible to obtain any official statistics of the amount of coal used per annum under steam-boiler plants, or of the number of steam-boiler plants at work in Great Britain.

The total capacity of engines used in mines and factories in 1907, including power plants for electric lighting and power, was 10,587,817 horse-power. This would seem to give about 10,000,000*l.* per annum as the total value of coal used in Great Britain for steam-raising purposes for engines only, apart from other purposes in the factory, such as heating, boiling water, &c. We think it will not be far wrong to take the value of the coal consumed in Great Britain as about 85,000,000*l.* per annum, of which approximately 17,000,000*l.* worth is used for steam-raising purposes. Taking the figures for the 100 tests, 18 per cent. saving on 17,000,000*l.* is just over 3,000,000*l.*, which represents the annual loss per annum to this country due to lack of scientific methods in the boiler-house; 20 per cent., which is probably a more correct figure, is 3,400,000*l.* per annum.

We wish to emphasise that this enormous loss is caused entirely by out-of-date methods of running boiler plants; that is to say, by loss of efficiency. In addition to the savings which could be made by correcting this error, very many individual boiler plants could also have their cost of steam production considerably reduced by buying coal to better advantage, and, as we have previously stated, the average saving from this source is probably 7 to 10 per cent.

In conclusion, we have given the results of four different industries—namely, cotton-mills, woollen-mills, paper-mills, and dyeing, bleaching, and calico-printing works—compared with the average for the 100 tests and the typical well-managed plant. From these figures we see that the 16 paper-mills are giving remarkably good results—average 76.65 per cent. efficiency, or about 14½ per cent. higher than the average. The 14 cotton-mills are slightly better than the average, with 65.11 per cent. efficiency, whilst the woollen-mills and the dyeing industries are below the average. There is, of course, not the slightest reason why, for example, the dyeing industry should not produce its steam as economically as the paper-making industry, and, on the figures given, by so doing reduce its coal bill about 17 per cent.

"La Guerre Moderne."—A book having for its title "La Guerre Moderne et ses Nouveaux Procédés," by Daniel Bellet and Will Darvillé, is now published by Messrs. Hachette and Co., Paris and London. As its title implies, it gives a description of the present war and of the means now available and resorted to in warfare. It is illustrated by 153 engravings. The book forms part of the Hachette series of popular works, and gives graphic accounts of the cost of war, of the questions of supplies, arms, ammunition, &c.; special chapters deal briefly with the naval and aeronautical sides of modern wars, and with the services rendered by railways and motor-cars. In regard to cost it is quite obvious, say the authors, that the figure for the present war will be found to be much above that for former ones; the expenditure for killing one man in the war of 1870-71 was calculated at 105,000 francs (4200*l.*). The corresponding figure was 75,000 francs (3000*l.*) in the Russo-Turkish war, and 102,000 francs (4080*l.*) in the Russo-Japanese war. The authors place the cost of a torpedo at between 16,000 and 18,000 francs (about 700*l.*), the cost of launching being 650 francs (26*l.*), and two out of every ten launched by submarines reach the target. They also state that Germany claims to be able to place in the service in war time one dirigible every three weeks. The last chapter deals with the criminal means used by the enemy in the present conflict; "the Germans," the authors say, "have by their brutal cruelty caused the human race to recede by centuries," and they describe a few of the barbarous methods resorted to—a few only, because they could easily fill volumes with an account of German atrocities. These atrocities will be made public in good time, but the subject is far too ghastly a one to be included in the Hachette "Bibliothèque des Ecoles et des Familles."

## CROSS-COMPOUND WINDING-ENGINES FOR THE CHISLET COLLIERY, NEAR CANTERBURY.

(*Concluded from page* 324.)

We publish this week the remainder of our illustrations of the cross-compound winding-engines erected at the Chislet Colliery by Messrs. Fraser and Chalmers, Limited, Erith. The throttle-valves are shown in detail by Figs. 21 to 38, Plate XXXIV. As has been previously explained (see Engineering, page 324 *ante*), one of these valves is mounted on each cylinder, the controlling gear being interconnected, so that both valves are operated together.

Both throttle-valves are of the same general design, though naturally that for the low-pressure cylinder is larger than its fellow. The two are connected to the same controlling lever, and are opened and closed simultaneously by hand, and without the aid of a steam relay. If ordinary double-beat throttle-valves be fitted to a winding-engine, trouble may ensue under certain conditions of winding. Thus if the driver both shuts off steam and reverses his engine in order to pull it up more quickly, the cylinders are converted into compressors. The relief-valves cannot always be relied on, and very high pressures may accordingly be attained within the cylinders unless the throttle-valve is of a kind that can lift under pressure from below. The valve, shown in Figs. 25, 26, 30 and 31, meets these conditions. It is of the "register" type, consisting of a flat plate with lights cut in it, which match with similar passages in the valve-seat when the valve is open. A small rotation of the valve gives, accordingly, a very large steam-way. In normal work this valve is not balanced, but is heavily pressed on to its seat below, and the two surfaces being scraped together, perfect steam-tightness is secured. The valve is, however, not rigidly held on to its seat, but can lift against the spring *h*, Fig. 25, should the pressure below exceed that in the steam-pipe. To enable the valve to be readily operated, a piston is provided in a chamber below it, as indicated at *d*, Figs. 25 and 27. A pilot-valve, fitting on to the facing B, Figs. 26 and 27, admits steam below this piston before every motion of the valve. This piston just raises the valve clear of its seat, so that it can be readily rotated. The end of this piston-rod abuts on the rounded end of the throttle-valve spindle, giving thus, when the valve is lifted, an almost frictionless support. The distance between the two spindles is adjusted by means of shims, as indicated in Fig. 37.

Details of the pilot-valve are shown in Figs. 32 to 36. The valve, it will be seen, is of the Corliss type, and by a slight rotation in one direction or the other puts the space under the piston *d* alternately in communication with high-pressure steam or with the cylinder steam-chest. The pilot-valve is operated by the same handle that works the main throttle-valve. The link-work interconnecting the two is clearly shown in Figs. 21 and 22. It will be seen that the main valve is actuated by a pair of Stanhope levers, *e* and *f*, Fig. 22. Hence, as the long arm of *e* swings over, through the arc indicated, there is at first practically no tendency whatever to move the main-valve spindle. The pilot-valve spindle is, however, linked up with *e* as indicated, and rotates at about the same speed as *e* does. Hence the first motion of the lever *e* merely opens this pilot-valve, and it is only after this is open and the main valve lifted that this latter valve begins to rotate. The spindle for this pilot-valve is shown separately in Figs. 23 and 24.

The gear for actuating the admission and exhaust-valves is of the usual Corliss type, as is indicated in Figs. 40 and 41, page 398, but the linkwork for the admission-valves is less heavy than would have been necessary had these been of the Corliss pattern. The trip-gear is under the control of the governor, the range of cut-off in the high and low-pressure cylinders being variable within zero and 40 per cent. of the stroke. At starting, the valves are not tripped at all, the engine taking steam the full stroke. As will be seen from the section of the high-pressure valve reproduced in Fig. 44, the lift is given by a cam motion, shaped so as to ensure the easy lift and quiet return of the valve to its seat when tripped, to which end a dashpot is also provided, as shown in Figs. 40 and 41, and to a large scale in Figs. 42 and 43. The low-pressure valves illustrated in Figs. 45 and 46, page 399, are of the same general design, but have four beats instead of two. When on its seat, the valve is just clear of the cam D, by which it is raised. The point of closing is controlled by the governor which determines the position of the cam *v*, Fig. 45. When the hook-lever is rotated upwards and round this cam the trip-finger comes in contact with the latter and detaches the hook *w* from the lever *u*, which is keyed to the same shaft as the cam D, Fig. 46. The dashpot valve is of the double-beat type, held down to its seat by a spring in the box *k*, Fig. 44, at the top of the valve spindle. The main valve-seat is held against the shoulder below it by the thin steel cage *g*, which abuts against the cover, as shown. It will be seen that the ports in this cage are cut at an angle, thus

ensuring a certain amount of elasticity, which prevents any possibilty of trouble from expansion strains, which might otherwise occasion distortion, and consequent leakage of steam.

prevention of over-winding, and provision is also made by which the governor automatically sets the brakes and cuts off steam in the case of the speed exceeding the normal by 5 per cent.

has cast-iron ends, the parallel portion being built up of ¾-in. riveted steel plates. The drum rests on its shaft at the ends only, as it has been found from experience that trouble is likely to arise if a central bearing is also provided, owing to the difference in the rigidity of the drum and the shaft. The parallel portion of the drum is covered with oak lagging, 4 in. thick, secured to the drum by ¾-in. bolts. A development of a portion of the drum showing these bolt-holes is reproduced in Fig. 50. The outer rims of the cast-iron end-pieces are plated with ¾-in. mild steel, on which the brake-blocks rub. As seen at *p p*, Fig. 47, this rim is stiffened by ribs. These, however, also have a further function, since they act as fans when the engine is running, and maintain a current of air over the surfaces under the brake-blocks when the drum is in motion. This air is compressed by the action of the ribs under the brake-rim, and escapes through holes provided for the purpose on the inner side. All liability of the rim to heat and crack is thus obviated. These ventilating ducts are clearly visible in Fig. 58, which shows a portion of the rim.

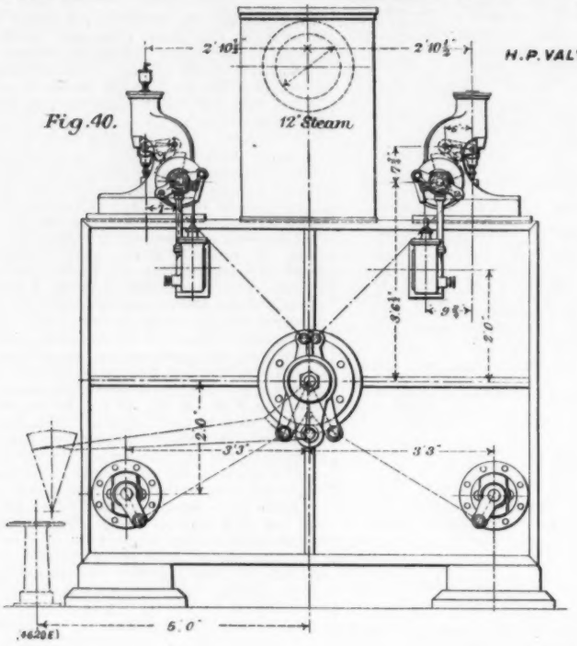



Fig. 40.

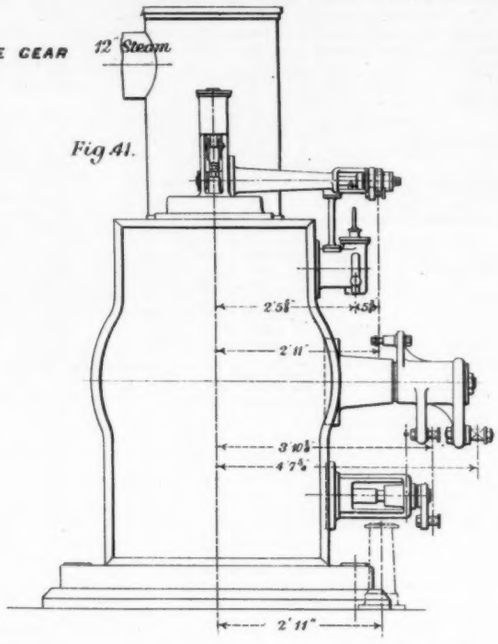



Fig. 41.

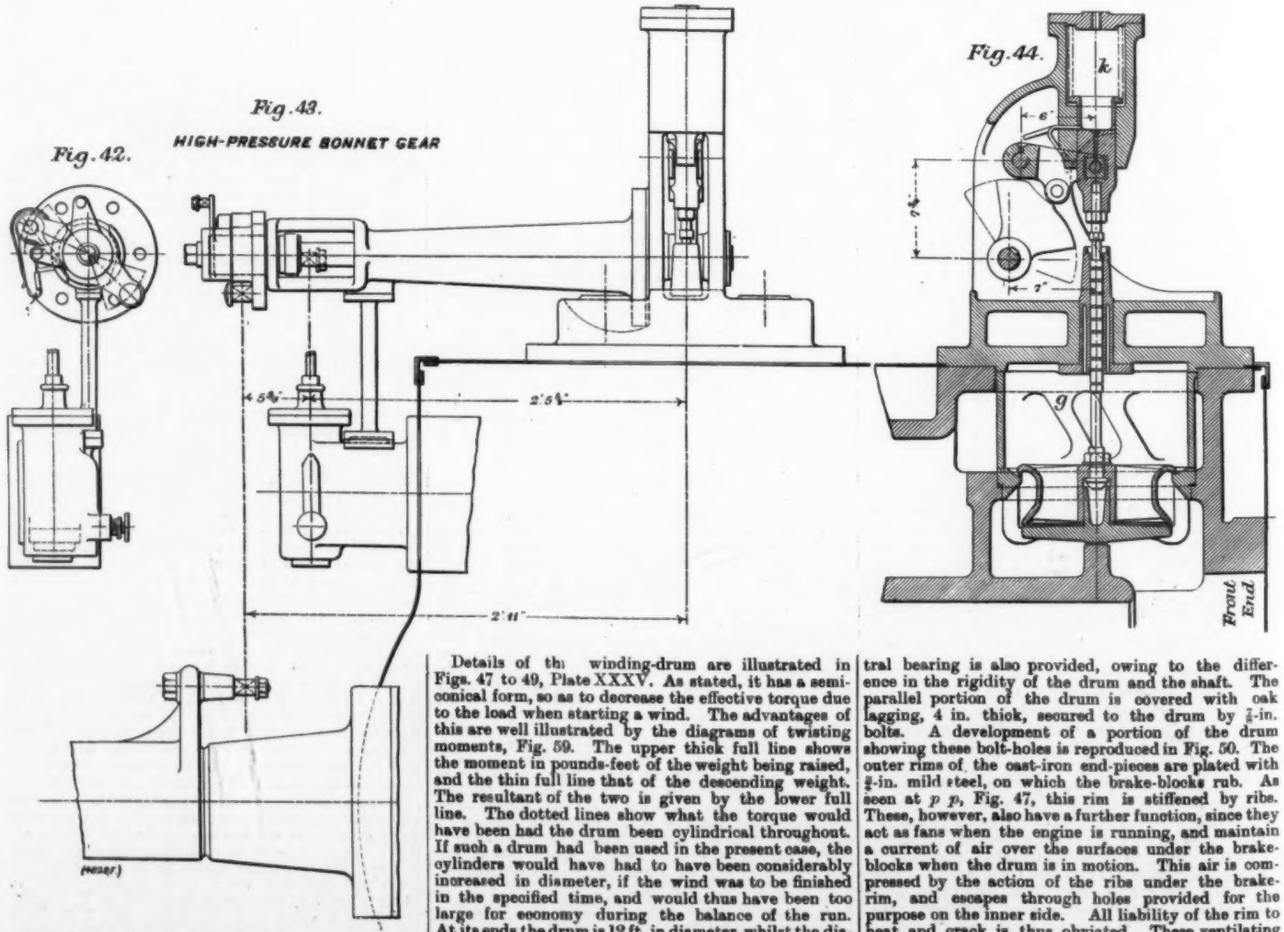



Fig. 42. Fig. 43.




Fig. 44.

The winding-drum is of the cylindro-conical type, so as to reduce the leverage of the load for the first few revolutions. Shaft indicators are, of course, provided, together with arrangements for the automatic

Details of the winding-drum are illustrated in Figs. 47 to 49, Plate XXXV. As stated, it has a semi-conical form, so as to decrease the effective torque due to the load when starting a wind. The advantages of this are well illustrated by the diagrams of twisting moments, Fig. 59. The upper thick full line shows the moment in pounds-feet of the weight being raised, and the thin full line that of the descending weight. The resultant of the two is given by the lower full line. The dotted lines show what the torque would have been had the drum been cylindrical throughout. If such a drum had been used in the present case, the cylinders would have had to have been considerably increased in diameter, if the wind was to be finished in the specified time, and would thus have been too large for economy during the balance of the run. At its ends the drum is 12 ft. in diameter, whilst the diameter of the parallel portion is 16 ft., and its length 6 ft. 6 in. There are four useful coils of rope on the smaller diameter, 2½ on the steeply-coned portion, and 24½ on the parallel portion of the drum. This drum

The arrangement of the brakes is best seen in Fig. 1, Plate XXIX., of our issue of March 31,

but one of the posts is shown in Figs. 51 and 52, Plate XXXV. Each post consists of a steel I-beam with cast-iron ends riveted on, as seen in Figs. 54 and 55. The brake-block $q$ is of wood. The two posts on opposite sides of the drum are connected together by a link at the top, as indicated. This link is screwed into a pivoted nut, shown in position at $r$, Fig. 51, and in detail in Figs. 56 and 57. By screwing up this nut the two brake-posts can be brought nearer together. As shown in Fig. 57, the nut is provided with a ratchet-wheel and lever. This lever is connected to linkwork so arranged that whenever the brake-post moves over this lever is caused to oscillate. As the brake-blocks wear, the total motion of the brake-posts increases, and finally becomes so great that the ratchet-lever moves so far that its pawl slips over a fresh tooth of the ratchet-wheel. Hence, when the brake-post returns, this wheel is moved through one tooth, thus turning the nut and shortening the link between the two brake-posts. All wear of the brake-blocks is thus automatically taken up.

The brake is operated by a steam relay, fitted with a cataract and with an overtaking-gear. The relay-valves are controlled by a hand-lever. The further this lever is pushed over, the heavier the load on the brake-blocks, and considerable nicety of adjustment is possible between the limits "hard on" and completely released. Moreover, owing to the automatic take-up gear described above the brake load corresponding to a given position of the hand-lever varies little from day to day.

The steam-relay cylinder is not shown in Fig. 51, but it stands above the cataract cylinder $s$. Normally the brake is held on, owing to the action of the weights $t$. In winding, however, this weight is lifted by admitting steam to the underside of the relay cylinder, which thus holds the brake off. Releasing the steam, the weights again apply the brake and are of themselves capable of holding the full load on the drum, but by admitting steam above the relay piston a still heavier braking pressure is obtainable, sufficient to hold the drum fast, not merely against the weighted cage, but against the full power of the main engine. The pressure on the brake lever is transmitted through a spring in the box $u$, which is shown to a larger scale in Fig. 53. On first applying the brake, this spring compresses, and the load on the brake-lever cannot exceed that due to the compression of the spring. A free compression of 8 in. is provided for, after which the washer above the spring comes hard on to the stop shown, jamming the blocks hard on.

The engine is fitted with steam reversing-gear. A Whitmore over-winder gear and controller gear are also fitted. The former shuts off steam, applies the brakes independently of the driver—should the latter be guilty of an oversight—whilst the controller gear, which is fixed between the over-winder governor and the cut-off cams on the valve gear, disconnects the governor when the driver reverses the engine, so that full steam may be applied to bring the cage to rest. On re-starting, the governor is automatically coupled up again to the tripping cams. The over-winder gear is illustrated in Figs. 60, 61, and 64, Plate XXXVI., details to a larger scale being represented in Figs. 62 and 63.

The apparatus consists of a pair of screws, right-handed and left-handed respectively, which are mounted vertically on the same standard as a governor. This governor is driven direct from the shaft of the winding-drum by means of a roller-chain, and as it is geared to the vertical screws, all three rotate together. On each screw are two nuts, which reproduce on a smaller scale the motion of the cages in the shaft. The upper of the two nuts, with which each screw is provided, has as its function the prevention of over-winding should the engineman fail to stop winding in time, or attempt, after a stop, to start the cages in the wrong direction. In such case the nut travelling further up its screw trips a gear, which instantly shuts off steam from the main engines, and puts the brakes full on. The lower nut on the same screw has a different object. When from one-half to two-thirds of a wind has been completed the engineman ought to begin to slow down. The two claws, seen in Figs. 60 and 61, are connected with the governor, and when the engine is running at its maximum speed they extend nearly horizontally across the path of the lower nut as it rises on its screw. If the engineman fails to check his engine, the nut catches on one of the claws, and, lifting it, trips a gear, which shuts off steam and gradually applies the brake. If, however, the engineman slows down, as he should do, the claws are gradually lifted by the governor out of the path of the rising nut, and the wind is completed without the trip-gear coming into action. It will be seen that these claws have several teeth, and the nut may catch on any one of these if the speed of winding is too high at any portion of the end of a run.

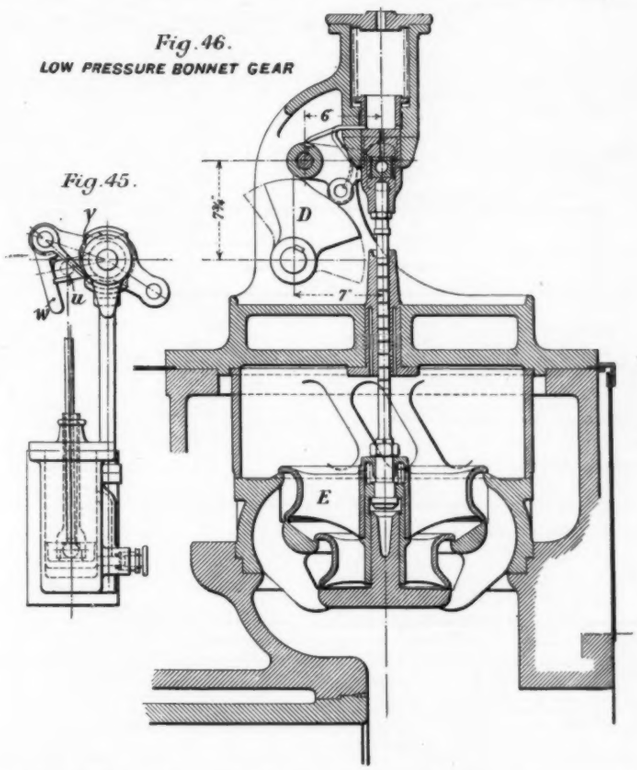
A general view of the engine is reproduced on Plate XXXVII. It is designed to work with steam at 145 lb. gauge pressure, superheated to 550 deg. Fahr., and the guaranteed consumption when making 66 full-load winds per hour is 14,100 lb. of steam, inclusive of jacket steam. This is equivalent to 33.6 lb. of steam per shaft horse-power per hour.

The bed-plates are of the trunk type, and bear on their foundations for their whole length. The crank-shaft has four-part bearings, with babbited boxes, and is drilled up the centre. The main bearings for the drum-shaft are 16 in. in diameter by 28 in. long, whilst the crank-pins are 8½ in. in diameter by 10 in. long. The piston-rods are, it will be seen, prolonged through the back covers as tail-rods, and they are cambered so as to be straight under their own weight and that of their pistons when at work. Hence no weight is carried by the glands, which are packed with U.S. metallic packings.

The engines have been designed to the requirements of Mr. Edmund L. Hann, 6, Park-place, Cardiff, the consulting engineer to the Chislet Colliery, Limited.

*Fig. 46.*
*LOW PRESSURE BONNET GEAR*

*Fig. 45.*




## SOME EFFECTS OF THE BULKHEAD COMMITTEE'S REPORTS IN PRACTICE.*

By A. T. WALL, A.R.C.Sc., Associate Member.

THE operation of the full rules laid down by the International Convention for the Safety of Life at Sea has been postponed on account of the fact that many of the nations who were signatories to it are now at war. These rules will presumably be made operative sooner or later, after the conclusion of hostilities. In the meantime, the Board of Trade have stipulated, for all foreign-going passenger steamers the keels of which are laid on or after January 1, 1916, that the standard of sub-division laid down for the "mixed type" by the International Convention must be adhered to. In regard to the sub-division of ships, the findings of the Convention were expressed in somewhat general terms, several of the subjects being left for further study and agreement. The Bulkhead Committee's Reports state in detail how the principles laid down in the Convention should be applied in practice, and modify certain of its provisions. The Committee consider that international agreement for these modifications should be obtained. In what follows it is assumed that the full recommendations of the Bulkhead Committee will eventually become law.

The object of the present paper is to show how these recommendations will affect the design, construction, and cost of several typical vessels. In addition, an approximate method is put forward which, it is hoped, will facilitate the application of the new rules in design work. It is not suggested that any one contribution of this nature could possibly cover the whole of the ground, and the title has been chosen to indicate this.

### PART I.—CHANGES IN DESIGN AND CONSTRUCTION.

An ordinary perusal of the Committee's Reports does not give much indication of the alterations that would be necessary in an existing ship to make her conform to the new rules. The matter must be gone into fully by means of much calculation and curve-plotting. Everyone is not in a position to do this, and the following cases help to show the changes that will generally be necessary in vessels of different types. If the number and spacing of the bulkheads are to remain as at present, the load draught would have to be much less. To maintain the existing load draught the number of bulkheads must be increased, and/or the bulkhead deck raised. A compromise can, of course, be made between these alternatives.

In setting out to show the actual changes that will be brought about, probably the best method to pursue is to examine ships of a type that have been built recently and are now in service. Many modifications that would have to be made to existing vessels, assuming it was required to make them fulfil the new regulations, are common to all types, but others depend on the special nature of the ship in question. In some cases the modifications required are small, while, in other instances, it is not too much to say, as will be shown later, that certain types of vessels will disappear altogether.

In all the vessels dealt with, the bulkheads in the existing ships are put into Lloyd's 1914-15 requirements, and the approximate extra first cost of the ship is given, due to the alterations by additional steel, deck coverings, cargo gear, water-tight doors, &c., as well as increased tonnage and coal consumption, and loss of dead-weight, if any of these takes place. In plotting the curves, the floodable length has been set out to half the length of the ship, so that the 45-degree set square can be used, as described in the scale of the paper† read by Professor W. S. Abell on "The Calculation of Stability in Non-Intact Conditions," in 1913, before this Institution.

The following is a list of items which may be required under the Bulkhead Rules, and which involve extra weight and increased cost of construction:—

1. Additional steel by—

(*a*) Additional bulkheads. (*b*) Increased scantlings of bulkheads. (*c*) Increased extent of bulkheads. (*d*) Increased scantlings of decks forming steps in water-tight bulkheads. (*e*) Increased shaft tunnel scantlings. (*f*) Increased scantlings of water-tight flats round shaft tunnels. (*g*) Extra coamings and trunks to hatches. (*h*) Fire-proof bulkheads. (*k*) Filling in wells. (*l*) Emergency exit trunks. (*m*) Trunks to hatches in decks forming water-tight steps in bulkheads. (*n*) Increased extent of double bottoms.

2. Water-tight doors—

(*a*) Increased number—(1) In 'tween decks; (2) in tunnels; (3) to trunks, particularly to hatches in water-tight steps. (*b*) More complicated system of operation. (*c*) No wood packing to frames. 3. Insulation behind wood lining, and doors to fire-proof bulks. 4. Emergency exits for passengers and crew. 5. Extra cargo gear, by extra holds. (*a*) Derricks, and probably derrick-posts.

* Paper read at the Institution of Naval Architects, April 13, 1916.

† Transactions of the Institution of Naval Architects, vol. lv. (Part I.), page 102; ENGINEERING, vol. xcv., pages 384, 405.

# SUB-DIVISION OF SHIPS ACCORDING TO BULKHEAD COMMITTEE'S REPORT.

*Fig.1.* CASE 1.

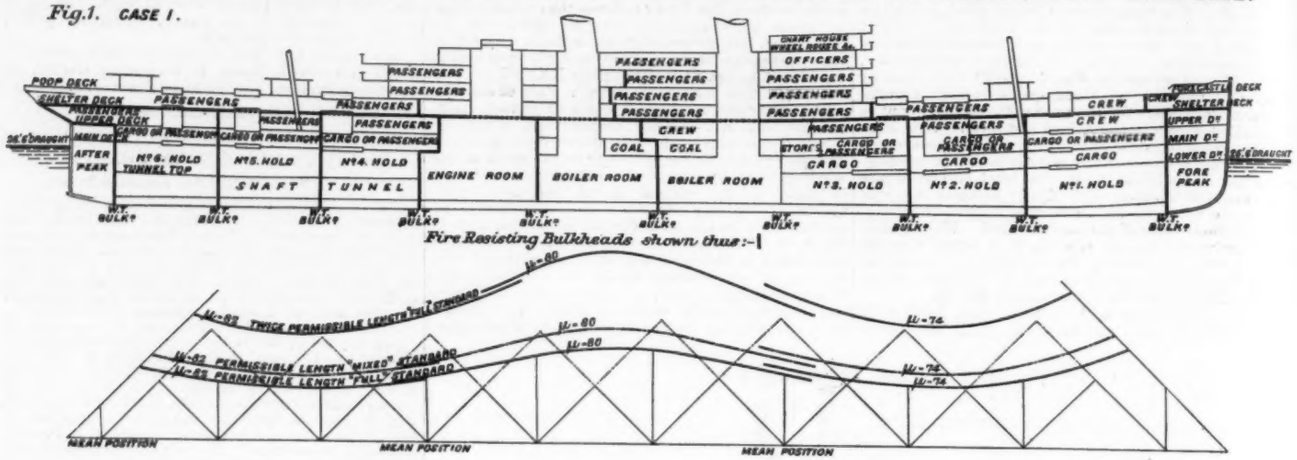



*Fig.2.* CASE 2.

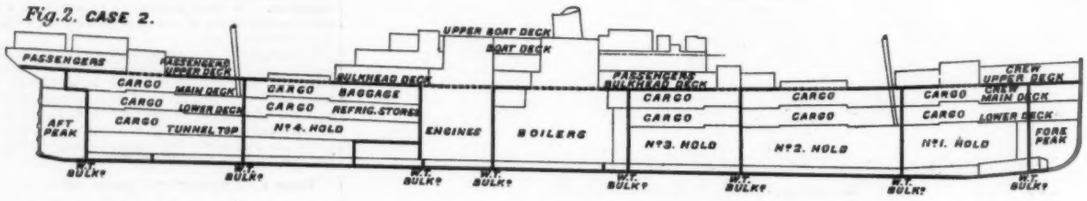



*Fig.3.* CASE 2.

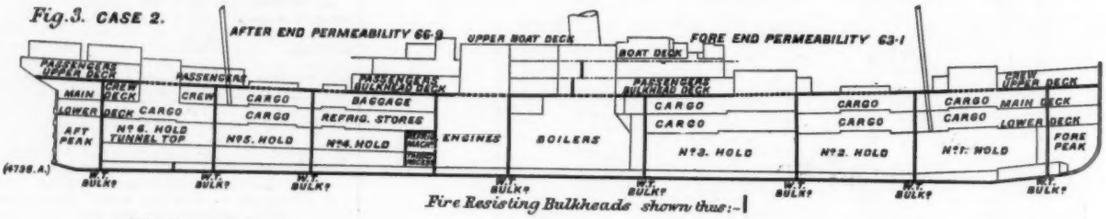



*Fig.4.* CASE 3.

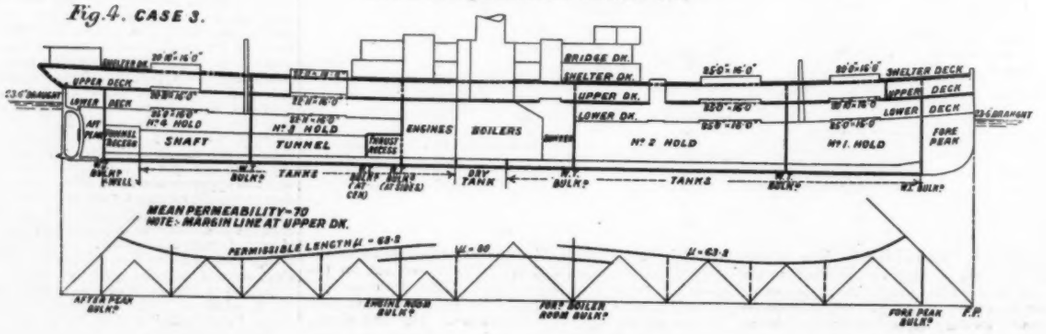
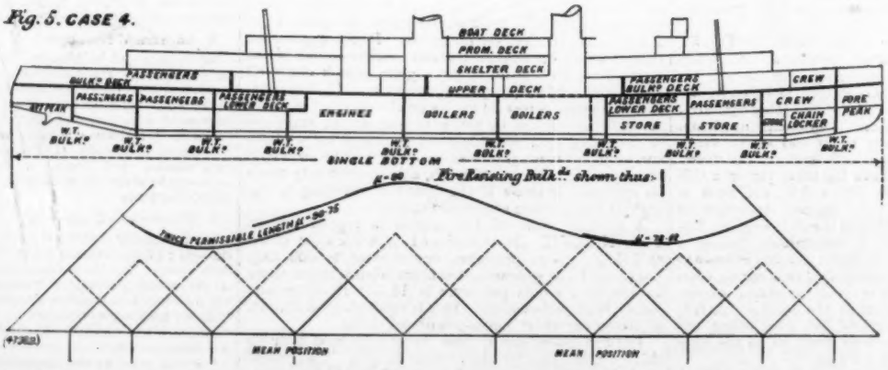



*Fig.5.* CASE 4.




(b) Winches and steam-pipes (which may affect size of auxiliary boiler). 6. Ash and slop shoots; water-tight valves on base with gearing, if the upper ends are below the bulkhead deck. 7. Enlarged pumping arrangements, including extra power necessary in emergency dynamo. 8. Extra deck coverings by filling in wells. 9. Extra valves and gearing to outlet pipes on ship's side. 10. Special side-scuttles.

The upkeep of a vessel built under the new rules will be greater than formerly, due to additional water-tight doors and gearing, cargo gear and winches, pumping arrangement water-tight valves and gearing, &c. All

# SUB-DIVISION OF SHIPS.

*Fig. 6. CASE 5, No. 1.*

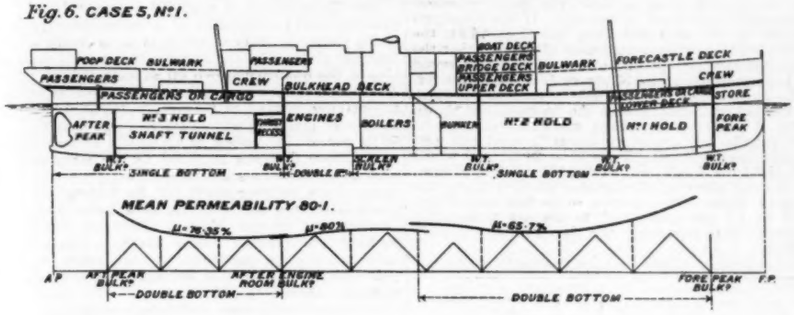



*Fig. 7. CASE 5, No. 2.*

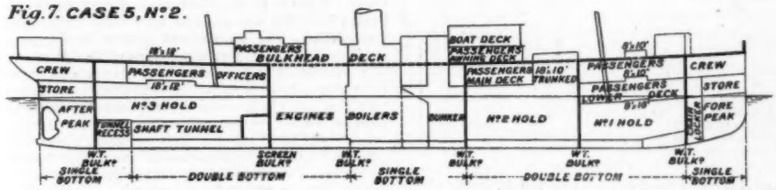



*Fig. 8. CASE 5, No. 3.*

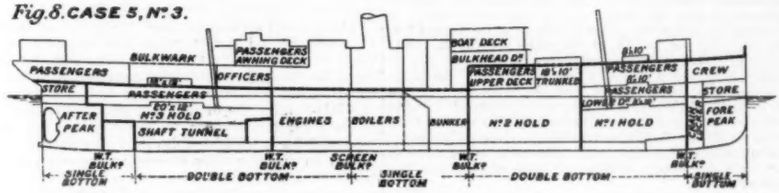
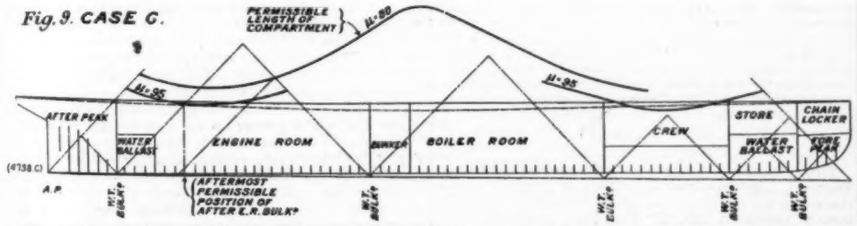



*Fig. 9. CASE C.*




the sub-division arrangements come under annual survey by the Board of Trade.

CASE 1.—Passenger Liner. Class: Steam—1 and 100 A1 at Lloyd's. Shelter-deck with freeboard. Principal dimensions—Length between perpendiculars, 535 ft.; breadth, moulded, 63 ft.; depth, moulded, 40 ft. (to shelter-deck). As originally designed, this vessel, the modified profile of which is shown in Fig. 1, reproduced on the opposite page, would require eight water-tight bulkheads under Lloyd's Rules, and these would only extend to the upper deck. At the load draught of 26 ft. 6 in., in order not to increase unduly the number of bulkheads in the ship, they would have to be carried to the shelter-deck, and even then two additional bulkheads are required, as shown in the profile, one forward and one aft. A large number of passengers are carried, so that the mean permeability of the ship exceeds 80 per cent., and the factor of sub-division is 0.461. Referring to the list already given of items involving additional cost, all of them would be incurred in this ship, with the exception of items 1 (*g*, *k*, and *n*) and 8. The additional gross steel added is about 180 tons, and the increased hold at each end of the ship introduces extra cargo gear. The water-tight door arrangement in the new ship is responsible for a very considerable addition to the cost. In the shelter 'tween decks doors were fitted in the water-tight bulkheads in order to facilitate the passenger and service arrangements, and the total number of water-tight doors in the new vessel is 18, as compared with five in the existing ship. All the water-tight doors below the water-line must be of type (5) or (6), and in working up the extra cost they have been assumed to be hydraulically operated—that is, of type (6). The load draught of 26 ft. 6 in. does not represent the maximum permissible under the load-line tables, or with the present number of bulkheads, and it could accordingly have been increased in the new vessel in order to balance the increased weight of hull, which is about 205 tons. This weight of hull, however, has to be carried about with the ship, and, taking a mean working draught of 24 ft. where the displacement is 15,400 tons, the approximate increased coal consumption is 1½ per cent. The total additional cost of hull brought about by the new rules is 3½ per cent. The tonnage of the ship is not appreciably affected, any more than the cubic capacity for cargo.

Under the "mixed" standard, the number of bulkheads required would still be the same as for the "full" standard. The table below summarises the statements made:—

| No. | Description of Ship. | Depth to Bulkhead Deck. | Mean Permeability. | Load Draught. | Percentage Addition over No. 1. | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Cost of Hull. | Weight of Hull. | Dead-weight. | Cubic Cargo Capacity. | Net Tonnage. |
| | | ft. | | ft. in | | | | | |
| 1 | Existing type .. | 32 | Over 80 | 26 6 | — | — | — | — | — |
| 2 | To "full" or "mixed" standard | 40 | Over 80 or 70 | 28 9½ | 3.5 | 2.8 | Nil | Nil | Nil |

CASE 2.—Intermediate Liner. Class: Steam—1 and 100 A1 at Lloyd's. Principal dimensions—Length, 480 ft.; breadth, moulded, 60 ft.; depth, moulded, 36 ft. 6 in. Fig. 2, opposite, shows the profile of this vessel as she would be built before the advent of the new rules. She would have the comparatively low speed of 14 knots, running at a block coefficient of 0.77. Her load draught under the Freeboard Tables would be 29 ft. 7 in., and gross dead-weight capacity 11,830 tons.

To give a reasonable dead-weight under the "full" standard of the rules, an additional bulkhead has been added aft, and the resulting load draught is 28 ft. 5 in., which causes a decrease in dead-weight capacity of 930 tons—that is, a reduction of 7.8 per cent. on the above. The profile of the vessel to the new requirements is shown in Fig. 3. Increased draught could be obtained by introducing additional bulkheads to those shown. By moving the machinery compartments aft about 15 ft., and putting in an additional bulkhead forward, the draught could be made about 29 ft. 7 in., as in Fig. 2; but, apart from the fact that the holds would be shorter and the cargo arrangements more complicated, excess trim by the bow in the loaded condition would probably taboo this arrangement.

The vessel in Fig. 3 loses dead weight on account of decreased load draught, and, to the extent of about 120 tons, by the additional weight of the ship brought about by fulfilling the requirements of the new rules.

If the vessel shown in Fig. 3 has only to conform to the "mixed" standard laid down by the Committee, the load draught could be 29 ft. 5 in., giving a decrease of dead weight as compared with the original ship of 240 tons—that is, 2 per cent. The extra cost of hull due to the new requirements is about 3.5 per cent., and is the same for the "full" and "mixed" standards. The total gross weight of steel added would be 96 tons. The assumption has been made that the tunnel recess would not be flooded if No. 5 hold were bilged. If this is not done, the draughts would be less than those given. To ensure this, at least one water-tight door must be fitted at the forward end of the tunnel recess.

In working up the extra cost the assumption has been made, as in Case 1, that the doors below the water-line are hydraulically operated. The after-peak bulkhead would cut into the crew's accommodation on the main deck, and necessitate the fitting of two horizontal sliding water-tight doors in the bulkhead there. Fire-resisting bulkheads would have to be fitted as shown in Fig. 3.

The extra cargo-hatch aft would involve additional cargo arrangements. Extra pumping appliances, with additional power in the emergency dynamo, would also have to be provided. The net tonnage of the ship would not be appreciably affected any more than the cargo capacity.

There is one feature brought out by comparison of the two profiles (Figs. 2 and 3) which shows that No. 2 hold in the modified ship is considerably shorter than in the original. This feature is of very frequent occurrence, since the centre of No. 2 hold is generally at the lowest part of the floodable length curve. This is unfortunate, since No. 2 hold is usually depended on to be the best in the ship. No. 3 hold is now the best, but its use either partially or wholly as a reserve bunker would spoil its usefulness for cargo. The table below summarises the statements made:—

| No. | Description of Ship. | Depth to Bulkhead Deck. | Mean Permeability. | Load Draught. | Percentage Addition Over No. 1. | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Cost of Hull. | Weight of Hull. | Dead-Weight. | Cubic Cargo Capacity. | Net Tonnage. |
| | | ft. in. | | ft. in. | | | | | |
| 1 | Existing type .. | 36 6 | 74.5 | 29 7 | — | — | — | — | — |
| 2 | To "Full" standard | 36 6 | 74.5 | 28 5 | 3.6 | 1.7 | 7.8 (less) | Nil | Nil |
| 3 | To "Mixed" standard | 36 6 | 70.0 | 29 5 | 3.6 | 1.7 | 2 0 (less) | Nil | Nil |

CASE 3.—Cargo-boat with less than fifty passengers. Class: Steam—1 and 100 A 1 at Lloyd's; shelter-deck, with freeboard. Principal dimensions: Length between perpendiculars, 380 ft.; breadth, moulded, 52 ft.; depth, moulded, 34 ft. (to shelter-deck). This vessel, as built before the advent of the new rules, would require six bulkheads under Lloyd's Rules, and they would be carried to the upper deck only. The profile of the vessel to the new requirements is shown in Fig. 4, on the opposite page. The load draught as a shelter-decker would be 23 ft. 6 in., and at this draught, taking the upper deck as the bulkhead deck, the curves of permissible length are shown underneath the profile. The necessary bulkheads are also shown, except that the boiler-room would still be too long. This arrangement of bulkheads could not, of course, be adopted; they would have to be carried to the shelter-deck, as shown in heavy dotted lines in the profile (Fig. 4). The vessel would then become an awning-deck ship, and the draught would be 23 ft. 8 in. There would be no necessity to increase the number of bulkheads, and the extra cost involved by the new rules would be about 3 per cent. There would, however, be a large addition to the net tonnage in some conditions. As the vessel was built, the shelter 'tween-decks were free from tonnage dues, unless cargo was actually carried there. With the new arrangement of bulkheads these between decks would always be measured in the tonnage, and represent a permanent addition of about 20 per cent.

If it were possible with the existing cubic capacity to utilise more dead-weight, as it probably would be, in certain trades, in a ship of this type, the vessel could be built as a full-scantling ship, and the draught could be 25 ft. 8 in., without introducing any additional bulkheads. The draughts allowable under Table A in the Load-Line Rules is 26 ft. 7 in. The next table, given overleaf, summarises the statements made.

CASE 4.—Cross-Channel steamer for carriage of passengers and mails. Class: Steam—2, shelter-deck, with freeboard and A 1 at Lloyd's for Channel purposes. Principal dimensions: Length on load water-line, 355 ft. (cruiser stern); breadth, moulded, 43 ft.; depth, moulded, 16 ft. 11½ in. (to upper deck).

This is the type of steamer referred to in paragraph 208 of the Committee's Second Report. They are generally of high speed and shallow draught. The machinery spaces are long, but the freeboard ratio is generally fairly

large, although the bulkheads are only carried to the upper deck. In this particular case the load draught is 11 ft. 6 in., and speed 23 knots, the freeboard ratio being 0.482. The profile to the new requirements is shown in Fig. 5, on page 400, with the necessary bulkheads and curves of permissible and twice permissible length shown beneath it. No special difficulty was experienced here in the design, although probably more bulkheads are fitted than would have been in the ordinary way. It is found that the steel scantlings prescribed in the new rules for this type of steamer do not increase the weight of the bulkheads over their weight to the old scantlings; if anything, there is a slight saving. By keeping the upper deck as the bulkhead deck, no additional watertight doors are introduced in the passenger accommodation, although one or two extra may be necessary in the shaft spaces.

| No. | Description of Ship. | Depth to Bulkhead Deck. | Mean Permeability. | Load Draught. | Percentage Addition Over No. 1. | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Cost of Hull. | Weight of Hull. | Dead-Weight. | Cubic Cargo Capacity. | Net Tonnage. |
| | | ft. | | ft. in. | | | | | |
| 1 | Existing type .. | 26 | 71.7 | 23 6 | — | — | — | — | — |
| 2 | "Full" or "mixed" standard | 31 | 71.7 or 70 | 23 8 | 3.0 | 1.0 | 0.4 | Nil | 20 |

In another Channel steamer that was tried the alterations that would have been necessary were more serious. This vessel was about 305 ft. long, with a beam of 45 ft. and depth to the upper deck 17 ft., whilst the load draught was 12 ft. 6 in. As at first arranged, steam was provided from two double-ended and one single-ended boilers, and the total length of boiler-room was 64 ft. This length is 31.5 ft. longer than the permissible length under the rule. By replacing the three boilers by two double-ended ones, it is possible to reduce the length of the boiler-room to 40 ft. This length, however, is still greater than the permissible length at the existing draught and depth. To make the length of boiler-room equal to the permissible length, the necessary increased depth to upper deck was determined, and the final combination of depth and draught proved to be, depth to upper deck 18 ft., load draught 12 ft. 10 in. This adds to the displacement, and if the machinery were retained as at present, the speed of the vessel would be slightly reduced. This increased depth could, of course, be obviated by carrying the bulkheads to the shelter-deck, but in a cross-Channel steamer this would probably prove a very inconvenient arrangement, and would increase the net tonnage.

CASE 5.—Passenger and cargo steamer. Class: Steam —2 and A1 at Lloyd's. Principal dimensions: Length between perpendiculars, 270 ft.; breadth, moulded, 43 ft.; depth, moulded, 21 ft. 6 in. Fig. 6, on the preceding page, shows the profile of a typical home-trade vessel for service between the East Coast and the Continent. The vessel is of the three-island type, and the wells forward and aft are enclosed by high bulwarks extending to the level of the poop, bridge, and forecastle decks. The load draught before the advent of the new rules was 19 ft., giving a freeboard ratio of only 0.135. The curves of permissible lengths of compartments are shown underneath the profile, together with the bulkheads that would be required to make the vessel satisfy the Bulkhead Committee's requirements. Such an arrangement could not, of course, be entertained. The load draught would have to be very small to avoid the introduction of extra bulkheads, and would have to be in the neighbourhood of 14 ft. 6 in. Such a small draught would only give a dead-weight carrying capacity of about 650 tons, as compared with 1870 tons at the existing draught of 19 ft. This arrangement would not be satisfactory, and the only practicable way out appears to be by raising the bulkhead deck.

The vessel, being 270 ft. long, falls under Chapter VI. of the Bulkhead Rules which apply to the sub-division of small vessels. The mean permeability of the ship is 80.1, and in consequence the length lies between 295 and $l$, the limits of length given by the Committee, which necessitate sub-division of the ship throughout the whole length. The resulting arrangement is shown in Fig. 7, where the bulkhead deck has been raised by filling in both the forward and after wells. With the arrangement of bulkheads shown the load draught could now be 18 ft. 11 in. Any draught in excess of this would require an extra bulkhead in the after hold, an innovation that would probably not find favour with owners. The dead-weight capacity of the vessel is therefore slightly decreased, and a slight reduction has been made in the cubic capacity of the cargo spaces, since the forward and after wells were always used in the existing ship for carriage of cargo as occasion demanded, and the substitution of a double bottom forward and aft in place of a single bottom decreases the hold capacities.

The modified ship will be more expensive to build and to run than the existing one. Additions to the first cost will be involved by increased weight of steel, principally in the water-tight bulkheads, and also in the shaft tunnel —double bottom in place of single bottom—and by filling in the wells, the total being 28 tons gross. There will also be additional deck coverings and water-tight doors in the 'tween decks. The total increase of first cost of hull will be about 3.5 per cent., and the addition to the weight about 37 tons. These items are probably not so important in their effect as the forced addition to the tonnage of the ship. The increase in the net tonnage is about 17.5 per cent. of the original. This must be a serious item in a boat continuously going in and out of port. In the existing ships dues would not have to be paid on the spaces in the forward and after wells, even if cargo was carried there, but now these spaces represent a permanent addition to the tonnage. If the mean permeability of the ship had been less than 76.94, the 270 ft. would lie between the limits of $l_1$ and $l_2$ that the Committee have set up, and in consequence she would only have to be divided for 35 per cent. of the length forward. In this case it would only be necessary to fill in the forward well and arrange the bulkheads as shown in Fig. 8. The double bottom would still have to be fitted outside the machinery spaces forward and aft. The maximum load draught would be 20 ft., and would be fixed by the Load-Line Tables, the existing subdivision forward allowing of a greater draught under the Bulkhead Rules. The addition to the first cost of hull would be 2.7 per cent., and to the net tonnage 8.5 per cent. This represents the ship to the "mixed" standard.

The table below summarises the statements made:—

| No. | Description of Ship. | Depth to Bulkhead Deck. | Mean Permeability. | Load Draught. | Percentage Addition over No. 1. | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Cost of Hull. | Dead-Weight. | Cubic Cargo Capacity. | Net Tonnage. |
| | | ft. in. | | ft. in | | | | |
| 1 | Existing type .. | 21 6 | 80.1 | 19 0 | — | — | — | — |
| 2 | Subdivided throughout length | 29 6 | 80.3 | 18 11 | 3.5 | 3.1 (less) | 3.4 (less) | 17.5 |
| 3 | Subdivided fore end only | 29 6 | 70.0 | 20 0 | 2.7 | 12.6 | 3.4 (less) | 8.5 |

CASE 6.—River ferry-boat, about 150 ft. long. Class: Steam—5.

In this case the modifications required to make the boat satisfy the new requirements are quite minor. The only compartment which exceeds the permissible length is the engine-room, but the machinery in this could easily be rearranged to allow the after bulkhead to be moved forward to bring the length of the room within the limit allowable. The vessel is shown in part profile in Fig. 9, together with the permissible length curves. The existing bulkheads are indicated, and the aftermost permissible position of the after engine-room bulkhead. If the after-peak bulkhead were still retained, this would introduce an additional bulkhead into the ship. The scantlings of the bulkheads under the new rules involve identically the same weight of steel as the existing scantlings.

In generally reviewing the cases of the six vessels dealt with, it should be noted that the changes made are not necessarily the only ones possible; there are also numerous matters of detail that occur in working up the general arrangements and steel plans which have not been remarked upon. Questions relating to horizontal and longitudinal sub-division and the sub-division of very large ships have not been touched upon. These omissions were essential in order to keep the paper within even the present dimensions.

*(To be continued.)*

THE SOCIETY OF MOTOR MANUFACTURERS AND TRADERS, LIMITED.—The new Council of this Society, elected at the recent annual general meeting, has unanimously re-elected Mr. E. Powell as president. The new vice-presidents are Mr. A. Brown and Mr. E. Hopwood.

THE INSTITUTION OF CIVIL ENGINEERS: AWARDS FOR PAPERS.—The Council of the Institution of Civil Engineers have made the following awards for papers read and discussed during the session 1915-16:—A Telford Gold Medal to Sir John Benton, K.C.I.E. (Eastbourne); a Watt Gold Medal to Sir George Buchanan, C.I.E. (Rangoon); a George Stephenson Gold Medal to Mr. F. W. Carter, M.A. (Rugby); and Telford Premiums to Mr. C. Carkeet James (London), Mr. D. E. Lloyd-Davies (Cape Town), and Mr. W. T. Lucy (Oxford). The awards for papers published in the Proceedings without discussion will be announced later.

SPECIAL EXPORT PRICES FOR GERMAN IRON PRODUCTS.—No doubt the depreciated exchange value of the mark has meant a very serious loss to German manufacturers during the war as far as their export trade is concerned, but it is a question whether their new methods will not in the long run do them more harm than good by driving away their buyers. Quite recently an arrangement has been entered upon between the German Steel Union and its Dutch connections, fixing the maximum price for basic steel at 8 gulden per 100 kg. (220 lb.), and 9 gulden per 100 kg. for Siemens-Martin ship steel sections. Foreign buyers henceforward will not only be required to make up for the unfavourable state of the exchange, but they will also have to pay, in addition, a suitable advance on the home price. The newly-formed export union for bar-iron has already fixed exports prices, which stand at 210 marks, against 140 to 145 marks on the home market. The new Dutch arrangement, already referred to, makes the export price to Holland for basic steel come out at about 190 marks per ton, whilst the prices in Germany, after the last rise, range from 112.50 marks to 127.50 marks for the various descriptions on the German home market, the figures for Siemens-Martin goods being respectively 210 marks for Holland, and 127.50 to 142.50 marks per ton on the German inland market.

## WATER-PRESSURE REGULATING APPARATUS.

THE illustrations on page 404 are reproduced from drawings and photographs of a water-pressure regulating plant, the duty of which is to maintain a fairly constant pressure at the end of a water main, irrespective of the quantity drawn off at intermediate points. The main in question supplies a large public building in an outlying district of Falkirk, N.B., at which point the water pressure was found to range from 20 lb. to 50 lb. per sq. in., owing to variations in the demands of the other districts supplied by the same main, so that at certain times an adequate supply to the upper floors of the building could not be maintained. The plant illustrated was therefore installed on the instructions of Mr. Charles Massey, C.E., engineer to the Falkirk and Larbert Water Trust, to whom we are indebted for the particulars given below, and we understand that it has satisfactorily overcome the difficulty above referred to.

The plant comprises a multi-stage centrifugal pump, driven through a pin-type flexible coupling by a variable-speed, shunt-wound interpole motor of the protected type. The set is supplied with direct current at 460 volts from the town mains, and when running at 1000 revolutions per minute will give a discharge of 83½ gallons per minute at a pressure of 21.6 lb. per sq. in. By increasing the speed to 1420 revolutions per minute the same discharge can be obtained at a pressure of 47.5 lb. per sq. in., and other quantities and pressures can, of course, be obtained at intermediate speeds. The plant is, however, required to give a constant discharge pressure, irrespective of the quantity delivered, and this is accomplished automatically by varying the speed of the motor by means of an hydraulic relay governor, detailed drawings of which are reproduced in Figs. 1 to 5. The complete installation is shown by the photographic illustration, Fig. 6, and the pump and motor are separately illustrated in Fig. 7.

The general arrangement of the governor is clearly shown in Figs. 1 and 2, while the essential working parts are drawn to a larger scale in Fig. 5. Water from the main in which the pressure is to be kept constant is admitted through the union connection on the left-hand side of Figs. 2 and 5 to the space below a flexible diaphragm, the pressure on which is balanced by a weighted lever. The weight is adjusted so that the desired constant pressure will keep the lever horizontal, and a higher or lower pressure will either raise the lever or allow it to fall. The movement of the lever actuates a pilot-valve controlling the flow of water to and from a vertical cylinder containing a piston which is connected by a piston-rod and chain to a rheostat in the field circuit of the motor. The cylindrical vessel on the right-hand side of Fig. 2 is a strainer provided to prevent dirt from interfering with the action of the pilot-valve, and Figs. 3 and 4 show the design of the sheaves over which the chain passes on its way to the rheostat. The various parts are visible in the back ground of Fig. 6, and the main switch, starting rheostat, and ammeter for the motor can also be seen in that figure.

When the set is running and the pressure in the main is normal, the weighted lever will be horizontal and the pilot-valve will occupy an intermediate position in which both passages to the governor cylinder are closed. The piston will then be stationary at some point depending on the delivery. If now the demand increases, the pressure will drop, and the diminished pressure on the diaphragm will allow the weighted lever to fall. This movement will draw the pilot-valve downwards into the position shown in Fig. 5, thus opening the lower passage between the valve and the cylinder to the water pressure, and the upper passage to the exhaust. The lower passage is, however, connected to the upper end of the cylinder, and *vice versâ*, so that the piston will move downwards, thus increasing the resistance in the motor field, and consequently increasing the speed.

The piston is connected to a wedge-shaped sliding-piece, on which a roller carried by a bell-crank lever is pressed by means of a spring, and the downward movement of the piston will therefore allow this lever to turn through a small angle in a counter-clockwise direction. The bell-crank lever is connected to a floating lever, which operates the pilot-valve, so that the latter will be lifted in this way as well as by the upward movement of the weighted lever due to the rise of pressure resulting from the increased speed. Eventually the passages to and from the cylinder will be closed again, and the piston will come to rest in some new position, and the set will continue to run at an increased speed.

A similar series of movements will, of course, take place in opposite directions if the pressure should increase. The movements, it should be explained, are not continuous, but proceed step by step, with an intervening pause, so that the speed of the set is gradually varied from time to time, according to the pressure, which is thus kept practically constant; in practice the pressure is found not to vary by more than 1 lb. or 2 lb. per sq. in. from the normal. The set must be started up by hand, but the control-

gear is so arranged that it is impossible to start up with a weak field. It is, however, automatically shut down during periods of light load. The pump, it should also be mentioned, is designed so that it is impossible for the water to be contaminated with oil from the bearings.

The main contractors for the complete plant were the British Electric Plant Company, Limited, of Glasgow, and the pump and motor were constructed at the Alloa Works of this firm. The sub-contractors for the starting and regulating apparatus described above were the Igranic Electric Company, Limited, of 147, Queen Victoria-street, London, E.C.

## THE LATE MR. JOHN TWEEDY.

We learn with regret of the death of Mr. John Tweedy, who, by his sound mechanical ability, high integrity in all that concerned the profession and business, and genial temperament, had exercised great influence not only in the design of marine engines, but in the counsels of the technical institutions devoted to engineering. Born in 1850, after a liberal education and training he commenced work in the general engineering factory, near Durham, of Messrs. Thomas Richardson and Sons, and served with this firm for several years, until he became chief draughtsman and general assistant manager at Messrs. George Clark's marine engine works, Sunderland, where he continued for some time. In both establishments he gained complete practical knowledge of work for the mercantile marine, and in 1879 was appointed manager to Messrs. Wigham Richardson and Co.'s engine works at Newcastle-on-Tyne. Here his engineering and commercial ability was early recognised by the late Mr. Wigham Richardson, a sound judge of men, and he was, within a few years of joining the firm, made a partner, and when the business became associated with Messrs. Swan and Hunter he continued a director, becoming ultimately the vice-chairman of the company. Messrs. Wigham Richardson and Co. were among the leaders in the design of high-speed merchant craft on the Tyne. Mr. Tweedy took up the work of lightening and improving the marine engine, and one of the notable services which he rendered was connected with the balancing of the engines. Others had been working at the same problem, and ultimately there was evolved the Yarrow-Schlick-Tweedy system, which had a most pronounced effect in reducing the vibration of ships due to the action of the unbalanced parts of the reciprocating engines.

Mr. Tweedy did not take much part in the public proceedings of the technical societies. He became a member of the Institution of Mechanical Engineers in 1882, and served on the Council from 1902 to 1908. Of the Institution of Naval Architects he became a member in May, 1889, and in 1903 was appointed by the Council to represent the Institution on the Consultative Committee to the Board of Trade. In 1902 he was elected President of the North-East Coast Institution of Engineers and Shipbuilders, of which he had been a member for a long time, and served for the usual two years. For some time also he was on Lloyd's Technical Committee. He had, however, to relinquish much active work owing to an illness which incapacitated him some seven or eight years ago. He went to Harrogate in order to accelerate, if possible, an improvement in his health, but died there on the 7th inst., at the age of sixty-six years.

He was twice married, his second wife being a daughter of the late Mr. Frank C. Marshall, of Messrs. Hawthorn, Leslie and Co., and she survives him. Of his two sons, one, Mr. George F. Tweedy, has followed him as Engineering Director of Messrs. Swan, Hunter and Wigham Richardson, Limited, and the other, Captain J. M. Tweedy, is now serving with the 5th Northumberland Fusiliers.

## INDUSTRIAL NOTES.

The President of the Board of Trade has appointed a committee for the textile industries and one for the electrical trades to consider their position after the war, with special reference to international competition, and to consider the steps which it is necessary or desirable to take in order to safeguard their position. The committee for the electrical trades is formed of the Hon. Sir Charles A. Parsons, K.C.B., F.R.S (chairman); Mr. J. Annan Bryce, M.P.; Mr. T. O. Callender; Mr. James Devonshire; Mr. B. M. Drake; and Sir John Snell. All communications are to be sent to the Secretary, Electrical Trades Committee, 7, Whitehall Gardens, S.W.

The President of the Board of Trade has also appointed Sir Joseph P. Maclay and Mr. Summers Hunter as additional members of the Shipping and Shipbuilding Committee; Mr. E. H. Marker, Board of Trade, has been appointed secretary to this latter Committee.

---

The Director of the Department of Labour Statistics states, in the *Board of Trade Labour Gazette*, that retail prices of food in the United Kingdom advanced during March by less than 1 per cent. The increase in the prices of flour and bread, which commenced in November last, had now been arrested, and a decrease of between 1 and 2 per cent. was shown. As compared with April 1, 1915, there was an average increase of 19 per cent. Taking the country as a whole, and making allowance for the relative importance of the various articles in working-class household expenditure, the average increase in the retail prices of food since the beginning of the war may be put at 49 per cent. This figure relates to food only, and in estimating the increased cost of living, this percentage must not be applied to the total family expenditure, but only to that proportion which is expended on food.

---

During February a slight fall, amounting to 0.8 per cent., was recorded in the general level of retail prices of certain of the more important articles of food in Berlin, as compared with January, while food prices as a whole were 85.6 per cent. above those of July, 1914. In arriving at these results allowance is made for the relative importance of the various articles in working-class consumption.

For eight out of nineteen articles considered the prices recorded for February show no change as compared with the previous month. As regards the other items the decreases in price slightly outweigh the rises, the result being that, on the whole, the general level showed a slight fall.

It can no longer be considered that the percentages quoted show the full extent to which the normal food supplies of Berlin are being reduced owing to the war. The prices recorded are in several cases maxima, above which retail dealers are not allowed to charge. Moreover, many of the articles may only be sold in strictly limited quantities—*e.g.*, bread, flour, butter, lard, milk; while others, such as peas and beans, would appear to be practically unobtainable at the ordinary shops. For the two last-named articles Berlin quotations have ceased for some months, and the percentages are based on the average prices for the remaining towns of Prussia. Lentils would appear to have practically disappeared from the Prussian markets, since no prices are recorded for February either for Berlin or for Prussian towns generally. The disappearance of this article from the returns has the effect of still further reducing the computed percentage rise in the general level of food prices since July, 1914.

---

The Press Bureau has issued a report made by Surgeon Karl Ohnesorg, United States Navy, of visits to certain working camps in or near the City of Berlin. In this report, it is stated that 300 prisoners of war are employed in the City of Berlin Gas Plant, 46 of whom are British; 25 work in the retort-room, and the remaining 21 at manual labour about the yards. The former receive 1.50 marks (1s. 6d.) a day, and the latter 75 pf. (8d.). At Niederschöneweide, 82 British are employed in a foundry; 25 are quartered outside the works in very unsatisfactory conditions; whilst 57 occupy the first floor of a three-story building. The prisoners receive 2.50 marks (2s. 6d.) daily. At Gladow 12 men, including a sergeant and a petty officer, are employed by farmers; the same conditions rule at Gross Glienicke, where there are nine British prisoners. Twenty-seven British, 10 of whom are corporals, are employed at the City of Berlin Electric Light Plant, their work being chiefly the unloading and wheeling of coal into the power-house. Among the other camps referred to in the report, we may mention Lichtenberg, where a large hide-curing company employs 39 British from the Doberitz camp, who work 9½ hours a day. At the City Slaughter-House there are 53 prisoners of war, 43 French and 10 British.

---

The annual report for 1915 of the Ship-Constructors and Shipwrights' Association states that it closed the year with a membership of 29,563, being a gain of 1295 members for the twelve months. The income, apart from the association's operation under the National Insurance Act, had been 80,405*l.* for the year, showing an increase of 10,000*l.* over the year 1914. The expenditure had been 64,341*l.* At the close of 1915 the total reserve fund of the association reached 176,084*l.* The increase of the total income for 1915 was almost wholly due to the National emergency levy.

---

The annual report for 1915 of the United Pattern-makers' Association states that it commenced the year with 8652 members, a membership which rose to 9019 at the close of the year, showing a gain of 367 members. The gain in membership in 1914 was 175 only. At the commencement of 1915 the total balance was 74,234*l.* The income from all sources amounted, in round figures, to 40,511*l.*, giving a total of 114,745*l.* The expenditure amounted to 21,759*l.*, leaving a balance of 92,986*l.* at the close of 1915.

## FOREIGN ENGINEERING PROJECTS.

We give below some data on two foreign engineering projects, taken from the *Board of Trade Journal*. Further particulars on these projects can be obtained from the Commercial Intelligence Branch, Board of Trade, 73, Basinghall-street, London, E.C.

*Portugal:* The *Diario do Governo*, Lisbon, publishes the text of a Bill, which has been presented to the Portuguese Chamber of Deputies, to authorise the Municipality of Alenquer to construct a broad-gauge railway from the station of Carregado to Alenquer. A period of ten months is provided for the presentation of plans for the approval of the Government, and work on the construction of the line will commence within ten months after their approval. Article 3 of the Bill proposes to authorise the Municipality to raise a loan of 260,000 escudos (about 37,600*l.* at current rate of exchange), to be devoted exclusively to the construction of the railway.

*Brazil:* The *Diario Official*, Rio de Janeiro, publishes a Decree (No. 11,982) approving the project for the reconstruction of the section of the Theresopolis Railway between Raiz da Serra and Theresopolis, a distance of 11,660 metres (about 7 miles) to cost about 71,300*l.*

## ROYAL METEOROLOGICAL SOCIETY.

The usual monthly meeting of this Society was held on Wednesday, the 19th inst., at 70, Victoria-street, Westminster, Major H. G. Lyons, D.Sc., F.R.S., President, in the chair.

Mr. E. V. Newnham, F.R. Met. Soc., read a paper entitled "*The Persistence of Wet and Dry Weather.*" The rainfall records of Greenwich, Kew, Aberdeen, and Valencia have been examined in order to find out how often rain falls on the following successive runs of one, two, three, &c., wet or fine days. The common notion seems to be that after a long run of wet days the chance of a fine day becomes greater, but statistics do not support this conclusion. Generally speaking, the expectation of rain on any day has been found to increase rapidly as the number of previous successive wet days increases, and to diminish with the number of successive fine days in the past. After very long spells of either kind the expectation of further rain reaches a practically steady value. The same conclusion holds for the expectation of rain in a given hour after different runs of wet and dry hours. In illustration some of the results may be quoted:—At Valencia, after seven days of drought rain falls on the eighth day 24 times out of 100, but after seven rainy days 86 times. For Kew the corresponding increase is rather less—namely, from 27 to 73.

A paper was also read by Professor H. H. Turner, F.R.S., entitled "*Discontinuities in Meteorological Phenomena.*" In a former paper certain critical dates, about six years apart (and formed according to a specified law, apparently related to the movements of the earth's axis), were specified for 200 years back, and it was shown that a number of meteorological data changed abruptly in character at these dates. In simple cases the intermediate chapters are alternately hot and cold or wet and dry, though other changes are more complex. In the present paper various new data are submitted to the same test, and give confirmatory results. The most noteworthy case is that of the mean temperatures at Paris, which confirm the dates for the past century. The changes at the critical dates are shown to be abrupt; the alternation is consistent for seventeen chapters out of eighteen, and it is shown to vary in amount according to a law which suggests the regular action of two disturbing causes, one of which has already been shown to play an important part in these phenomena, and has a period of about forty years, the other, of about fifty years, appearing clearly in Mr. Douglass's measures of Californian tree-rings.

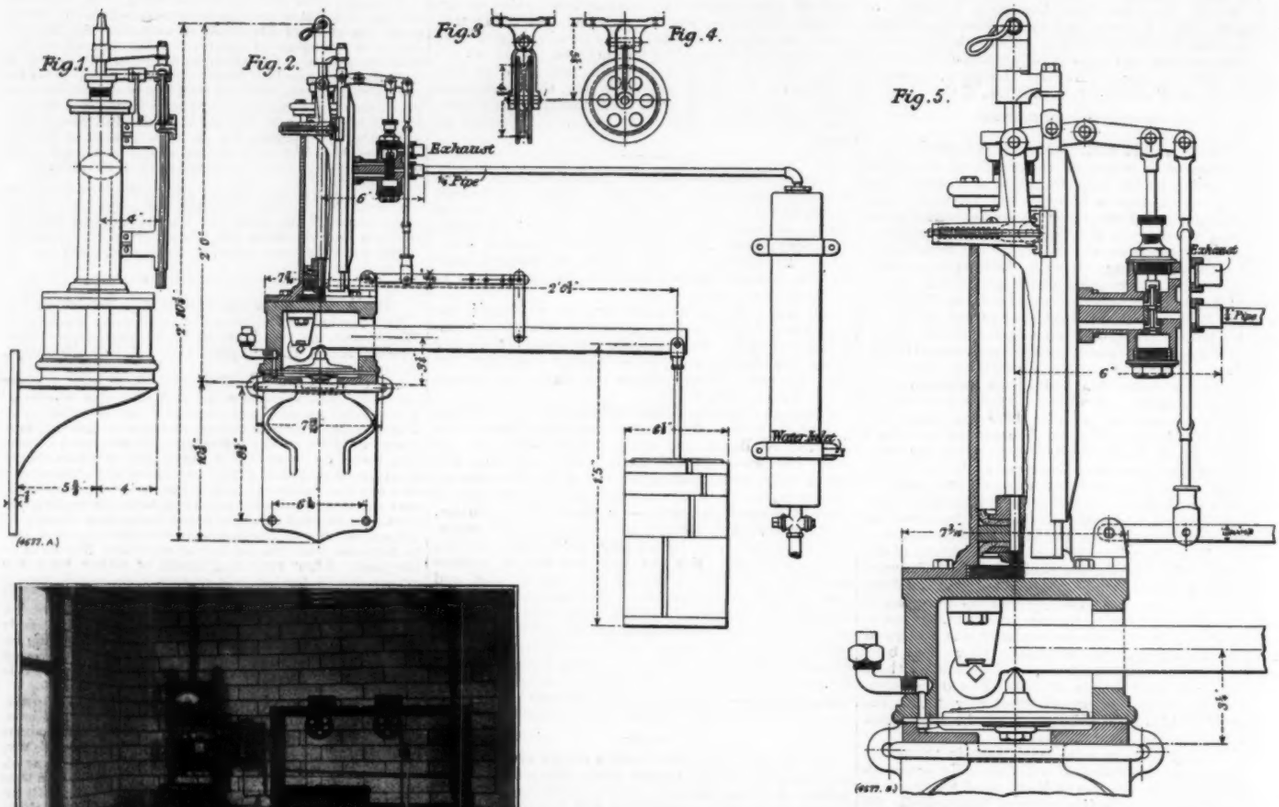
---

The Committee on Neglect of Science.—A meeting will be held at the invitation of this committee, of which Sir Ray Lankester, K.C.B., F.R.S., is chairman, on Wednesday, May 3, in the rooms of the Linnean Society, Burlington House, Piccadilly, London. Lord Rayleigh, O.M., Past-President of the Royal Society and Chancellor of the University of Cambridge, will take the chair at 3 p.m. The following resolutions will be submitted:—1. That in the opinion of this meeting it is a matter of urgency, in order to promote national efficiency in the near future, that the natural sciences should be made an integral part of the educational course in all the great schools of this country, and should form part of the entrance examination of the universities of Oxford and Cambridge as well as of the newer universities. 2. That it is in the highest degree desirable that the Government should exercise the large power which it possesses of encouraging the study of the natural sciences and thereby increasing the efficiency of our public servants (*a*) by assigning capital importance to the natural sciences in the competitive examinations for the Home and Indian Civil Service; (*b*) by requiring some knowledge of the natural sciences from all candidates for admission to Sandhurst. 3. That this meeting is of the opinion that the method indicated in Resolution 2 is the only one by which it is practicable to bring about the desired change in the attitude of the schools and colleges throughout the country towards the natural sciences and to make some knowledge and understanding of those sciences general. As the results of such changes will only develop in the course of years, it is urgent that the matter should be at once taken in hand by His Majesty's Government. 4. That the committee are authorised to take such steps as they may consider appropriate in order to bring these views to the notice of His Majesty's Government.

# WATER-PRESSURE REGULATING APPARATUS.

**CONSTRUCTED BY THE IGRANIC ELECTRIC COMPANY, LIMITED, ENGINEERS, LONDON AND BEDFORD.**

*(For Description, see Page 402.)*



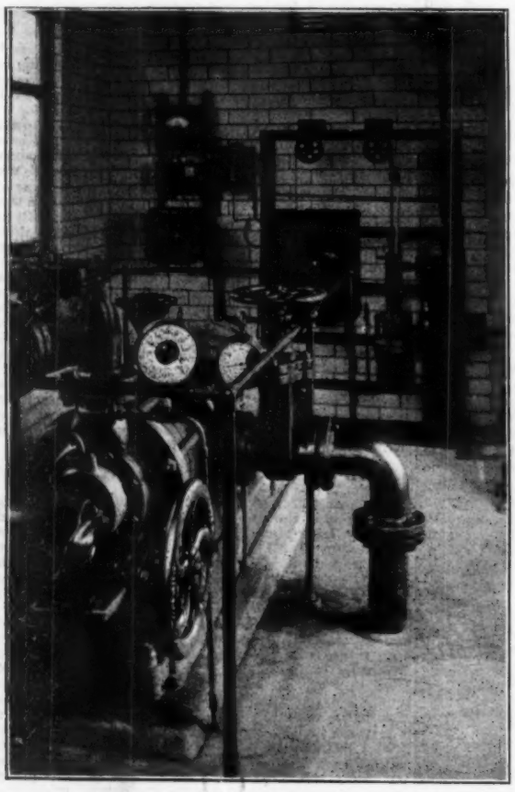



FIG. 6.

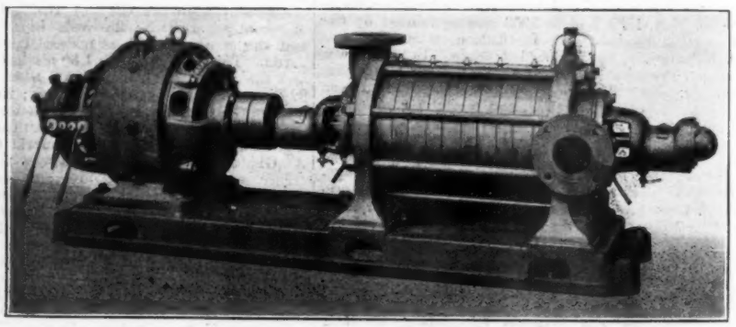


FIG. 7.

THE MAKING OF LANOLINE.—The Australian Minister for Customs recently called attention to the waste of millions of pounds of lanoline from the numerous wool-scouring establishments in the Commonwealth. The subject had previously been dealt with by Mr. J. Brownlee Henderson, Government Analyst of Queensland, who pointed out that lanoline existed in wool to the extent of 14 per cent. The German wholesale price for lanoline at that time—not the mixture of lanoline, vaseline, and water sold in collapsible tubes—was 11d. per pound, so that from this source a very large quantity of material must have been thrown away in Australian wool scours. "Personally," said Mr. Henderson, "I think there is certainly a fair margin of profit showing here. It is not at all likely that a process which is worked successfully and well known in Germany would cost a great deal more to work here with such a store of raw material to hand." Mr. Henderson also called attention to the presence of water soluble potash salts in wool. From raw wool he showed that from 7 per cent. to 10 per cent. was obtainable without damaging the wool. In some Continental countries it paid handsomely to extract the salts by washing the wool and evaporating the solution, but he thought that the evaporation could be much more cheaply accomplished in the dry air of Western Queensland than by artificial means in Europe. These statements have caused considerable interest in Australia, where the possibility of establishing a new industry in the making of lanoline is being seriously discussed.

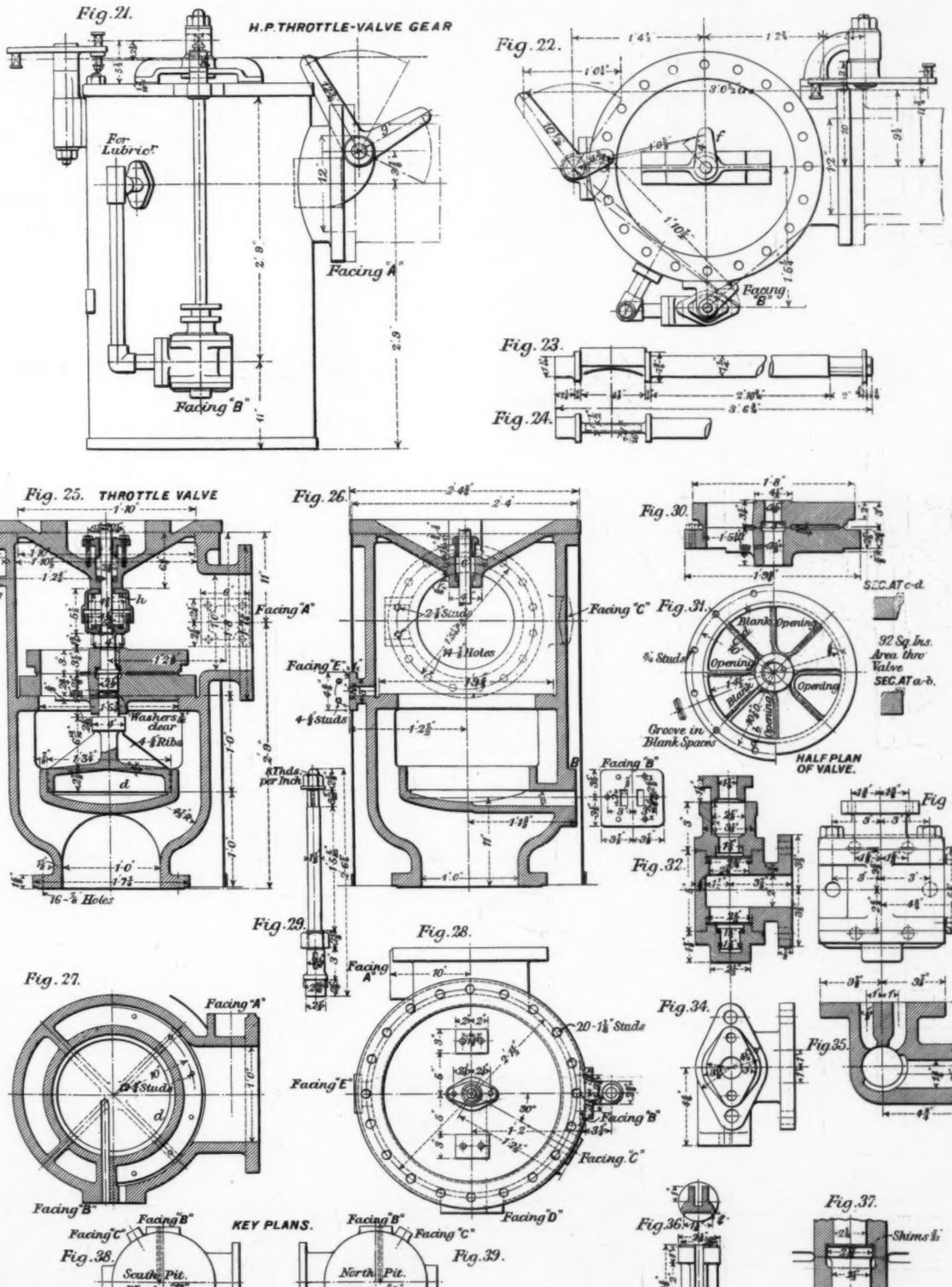
WESTERN TELEPHONY.—The chief telephone event last year in the Western world was the opening of a transcontinental line from New York to San Francisco. The financial and other conditions relating to the Bell system last year were satisfactory, the number of stations in operation at the close of the year being 9,151,221, showing an increase of 502,238 as compared with December, 1914. The system has now no less than 10,536,837 miles of underground wire, the conduits involving a cost of 94,500,000 dols. The cables in the conduits also represent a cost of 111,200,000 dols., making a total for underground plant of 205,700,000 dols.

CANADIAN METALLURGY.—The production of pig-iron in Canada last year was officially estimated at 815,820 tons, of the value of 11,592,819 dols. The corresponding production in 1914 was 699,253 tons, so that the output increased last year to the extent of 17 per cent. Of last year's production 803,595 tons were made with coke and and 12,225 tons with charcoal. Of the ore dealt with, 261,379 tons came from Canadian mines and 1,306,580 tons were imported (750,535 tons from Newfoundland). The Canadian production of steel ingots and castings last year was 911,013 tons, as compared with 739,857 tons in 1914. Iron ore was shipped from the Wabana Mines, Newfoundland, last year to the extent of 775,402 tons—716,185 tons to Cape Breton, and 59,217 tons to England. The corresponding shipments of Newfoundland iron ore in 1914 were 570,928 tons, of which 377,607 tons were forwarded to Cape Breton and 193,321 tons to Europe and the United States.

# THROTTLE-VALVES FOR CROSS-COMPOUND WINDING-ENGINES AT CHISLET COLLIERY.

CONSTRUCTED BY MESSRS. FRASER AND CHALMERS, LIMITED, ENGINEERS, ERITH.

(For Description, see Page 397.)




(To Face Page 398.)

# DRUM FOR CROSS-COMPOUND WINDING-ENGINES AT CHISLET COLLIERY.

CONSTRUCTED BY MESSRS. FRASER AND CHALMERS, LIMITED, ENGINEERS, ERITH.

(For Description, see Page 397.)

Fig. 47. WINDING DRUM

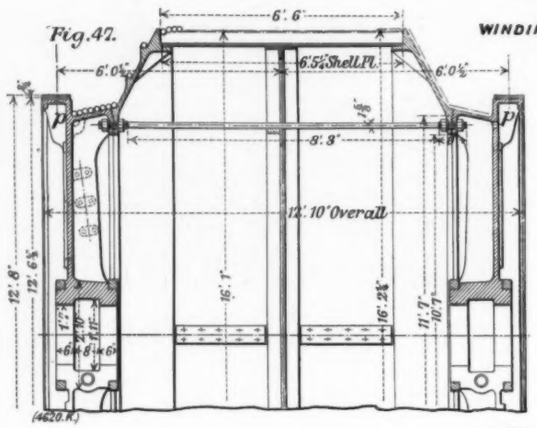



Fig. 48.

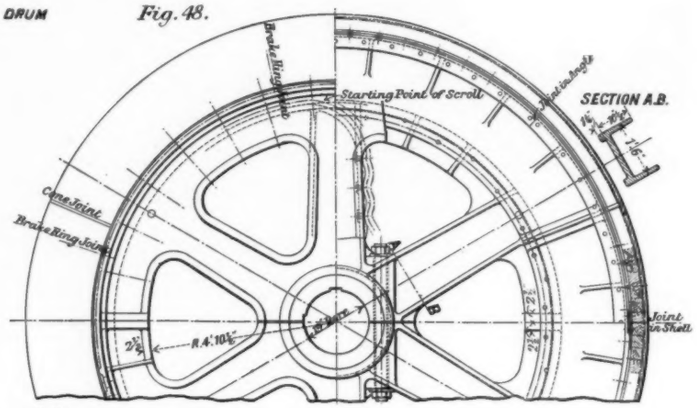



Fig. 49.

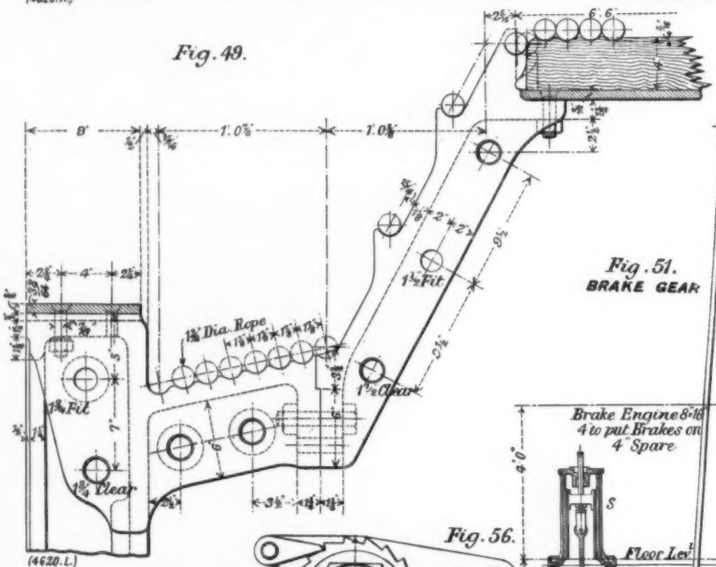



Fig. 51. BRAKE GEAR

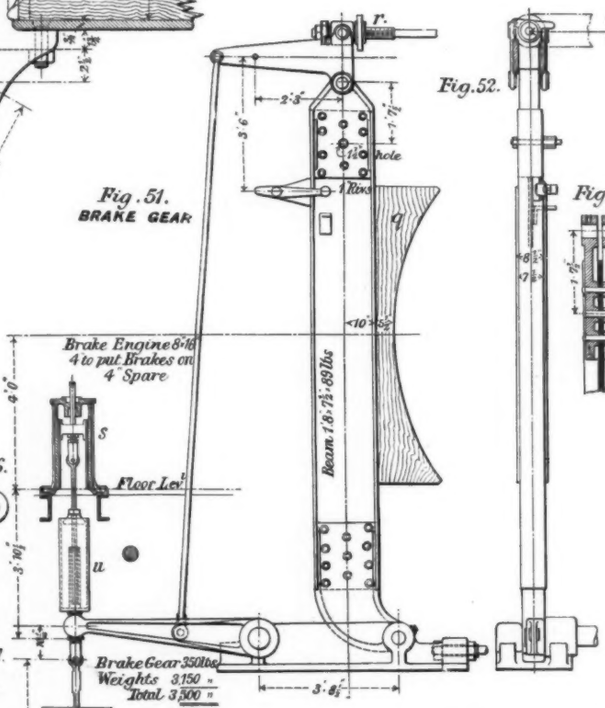



Fig. 52.

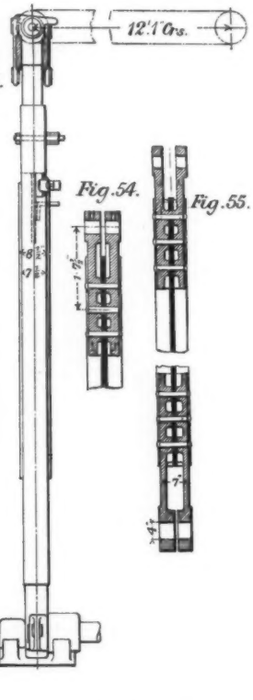



Fig. 54.



Fig. 55.



Fig. 56.

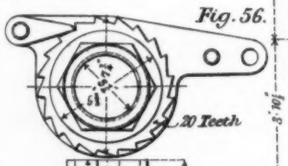



Fig. 50.

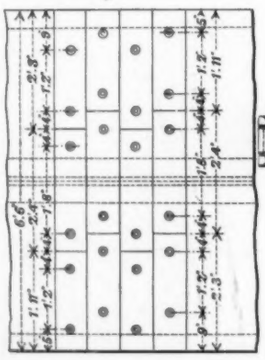


Fig. 57.

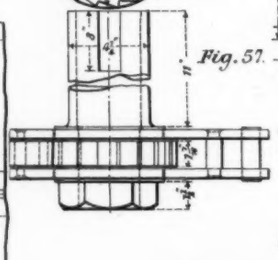


Fig. 53.

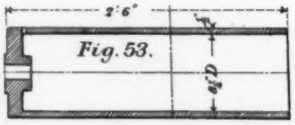
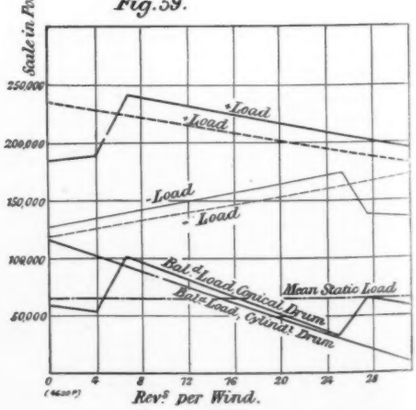


Fig. 58.

THE CHISLET COLLIERY LTD. STURRY.
32"-53"-66" COMP.ᴺ WINDING ENGINE
STATIC LOAD CHART.
12'0" TO 16'0" CYLINDRIC CONICAL DRUM. NET LOAD 8400 LBS. FROM 1500 FEET.

Fig. 59.



# OVER-WINDER GEAR FOR WINDING-ENGINES AT CHISLET COLLIERY.

CONSTRUCTED BY MESSRS FRASER AND CHALMERS, LIMITED, ENGINEERS, ERITH.

(*For Description, see Page* 397.)

*Fig.60.*

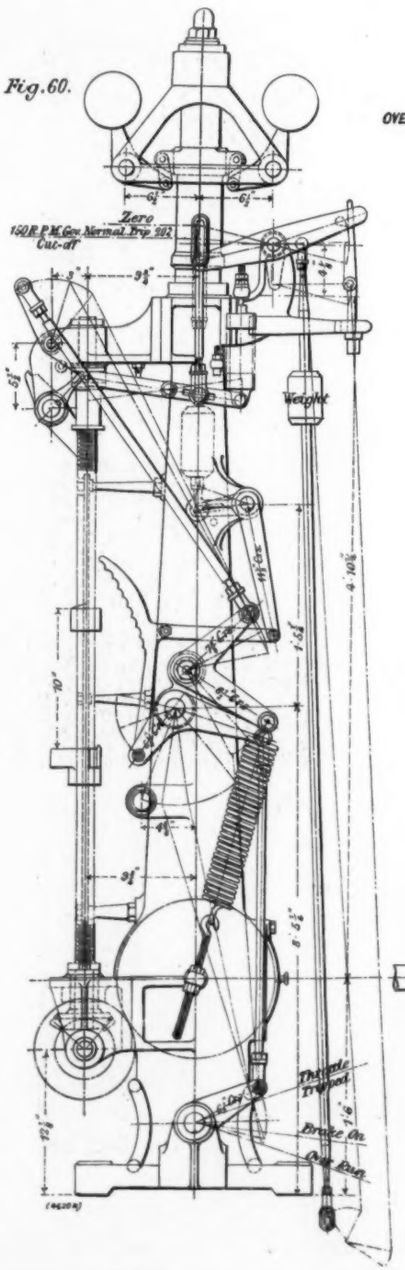



*Fig.61.*
OVERWINDER GEAR

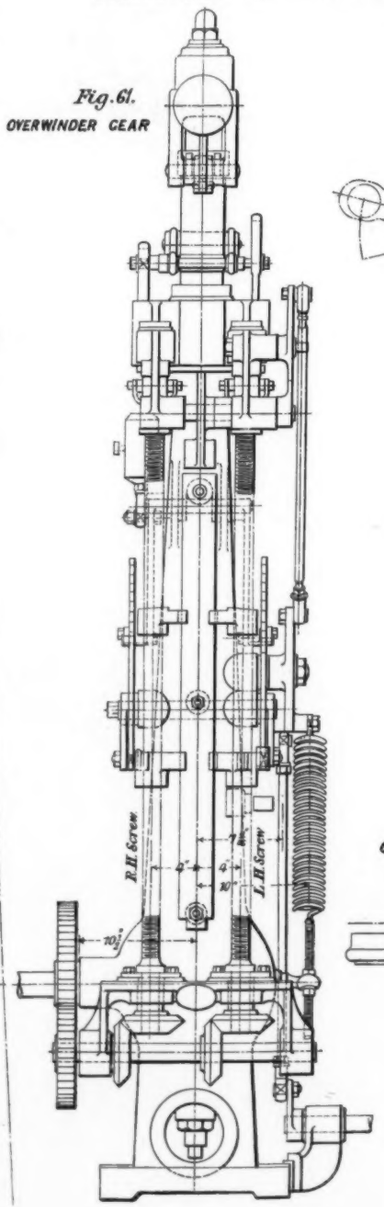



*Fig.62.*

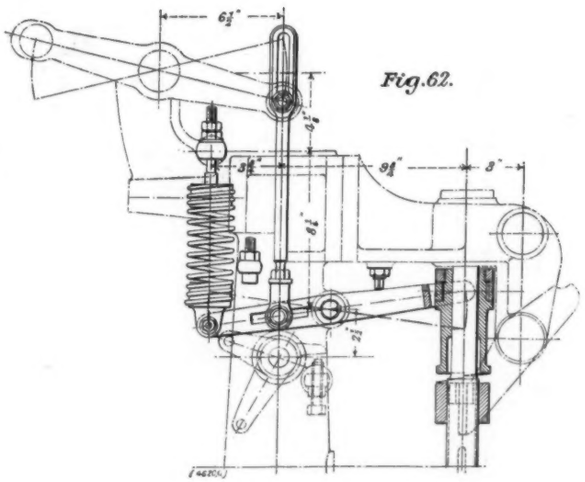
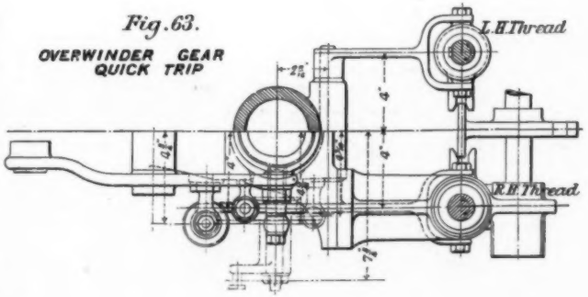


*Fig.63.*
OVERWINDER GEAR
QUICK TRIP



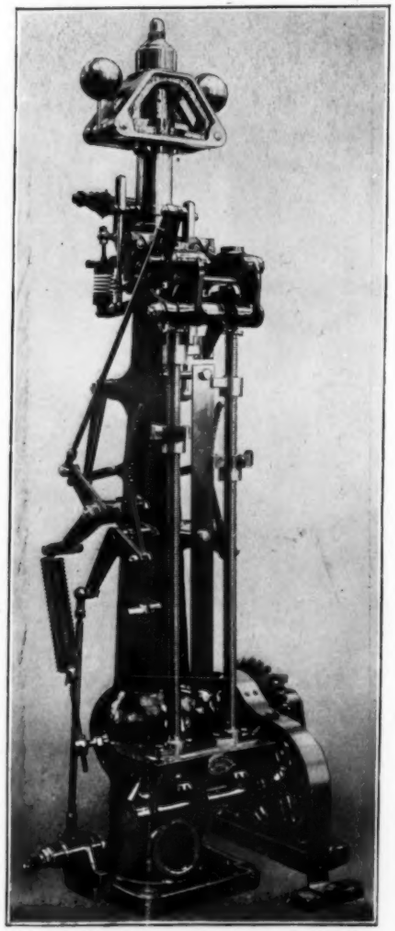



FIG. 64.

# CROSS-COMPOUND WINDING-ENGINES AT CHISLET COLLIERY, NEAR CANTERBURY.

CONSTRUCTED BY MESSRS. FRASER AND CHALMERS, LIMITED, ENGINEERS, ERITH.

(*For Description, see Page* 397.)

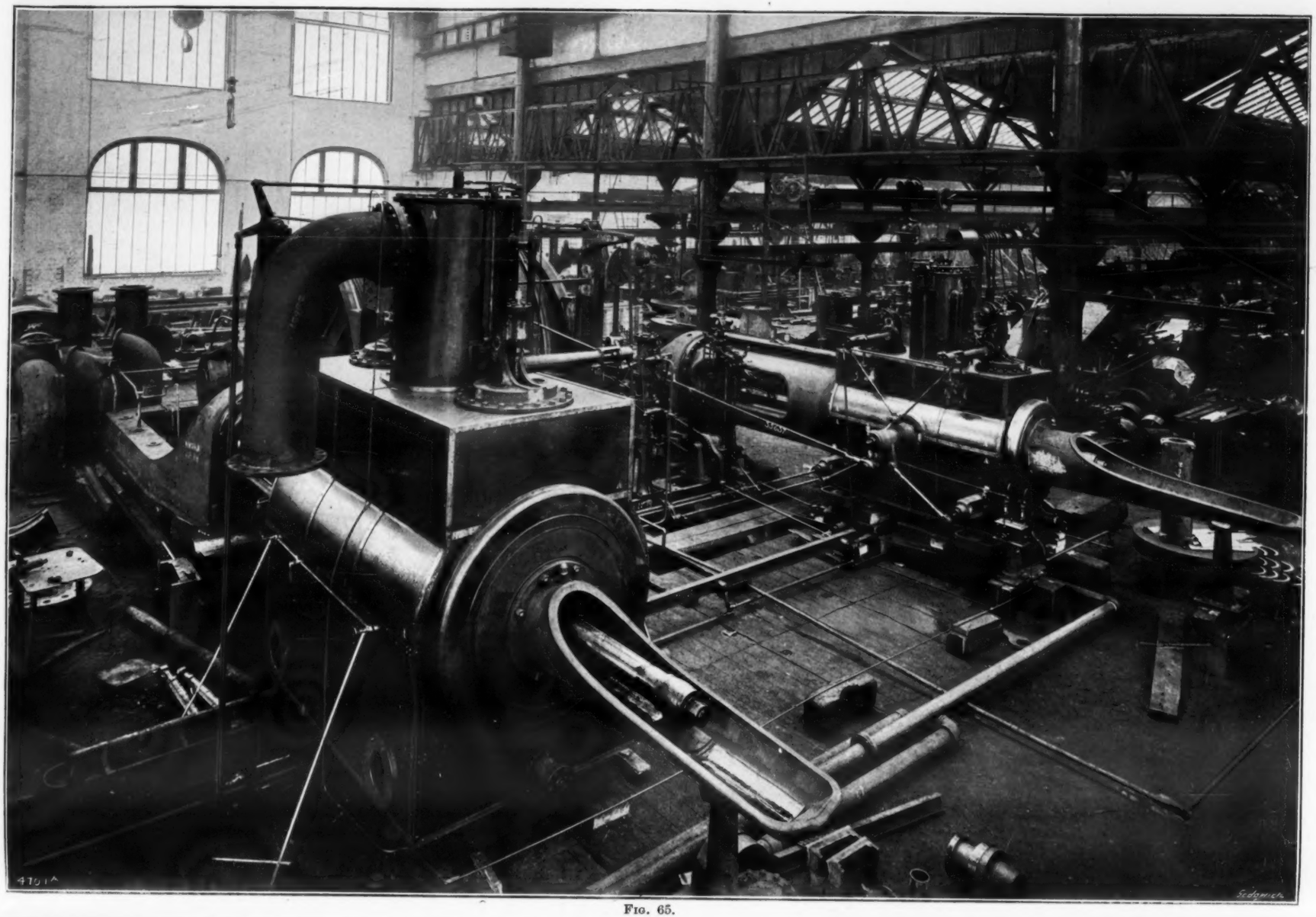


FIG. 65.

(*To Face Page* 399.)

## AGENTS FOR "ENGINEERING."

AUSTRALIA: Gordon and Gotch, Limited, Melbourne; Sydney; Brisbane; Perth. Turner and Henderson, Sydney, N.S.W. T. Willmett and Co., Townsville, North Queensland. W. C. Rigby, Adelaide, South Australia. Melville and Mullen, Melbourne, Victoria.
CANADA, Toronto, Ont.: Wm. Dawson and Sons, Manning Chambers. Montreal: Sells, Limited, 203, Shaughnessy Building, McGill-street.
EDINBURGH: John Menzies and Co., 12, Hanover-street.
FRANCE, Paris: Boyveau and Chevillet, 22, Rue de la Banque. For Subscriptions and Advertisements, Librairie B. Tignol, Bibis, Quai des Grands-Augustins, Paris. Also for Advertisements, Agence Havas, 8, Place de la Bourse.
GLASGOW: William Love.
INDIA, Calcutta: Thacker, Spink and Co. Bombay: Thacker and Co., Ltd.
ITALY: U. Hoepli, Milan, and any post-office.
LIVERPOOL: Mrs. Taylor, Landing Stages.
MANCHESTER: John Heywood, 143, Deansgate.
NEW ZEALAND: Gordon and Gotch Proprietary, Limited, Wellington, Auckland, and Christchurch.
NORWAY, Christiania: Cammermeyer's Boghandel, Carl Johans Gade, 41 and 43.
ROTTERDAM: H. A. Kramer and Sch.
SOUTH AFRICA: Central News Agency, Limited, Head Office—Johannesburg; and Pretoria, Cape Town, Port Elizabeth, Bloemfontein, Durban, and their various branches and bookstalls throughout South Africa. Also Cape Town: Wm. Dawson and Sons, 31, Long-street.
TASMANIA: Gordon and Gotch Proprietary, Limited, Launceston; Hobart.
UNITED STATES. For Subscriptions, New York: W. H. Wiley, 432, Fourth Avenue. Chicago: H. V. Holmes, 947-956, Monadnock Block. For Advertisements, J. S. Allan, 508, Stratford Avenue, Bridgeport, Conn., U.S.A.

## ADVERTISEMENT RATES.

The charge for advertisements is three shillings for the first four lines or under, and eightpence for each additional line. The line averages seven words. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

**Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.**

## SUBSCRIPTIONS, HOME AND FOREIGN.

"ENGINEERING" may be ordered from any Newsagent in town or country and at railway book-stalls, or it can be supplied by the Publisher, post free, at the following rates, for twelve months, payable in advance:—

For the United Kingdom..... £1 15 6

The increase in the annual subscription is entirely due to the new postage rates on newspapers.

For Canada—

Thin paper copies ..... £1 11 6 ($7.65)
Thick „ ..... £1 16 6 ($8.75)

For all other places abroad—

Thin paper copies ..... £1 16 0
Thick „ ..... £2 0 6

When foreign subscriptions are sent by Post-Office Orders, advice should be sent to the Publisher.

Foreign and Colonial subscribers receiving incomplete copies through newsagents are requested to communicate the fact to the Publisher, together with the agent's name and address.

All accounts are payable to "ENGINEERING," LIMITED. Cheques should be crossed "Union of London and Smith's Bank, Limited, Charing Cross Branch." Post-Office Orders should be made payable at Bedford-street, Strand, W.C.

**Offices for Publication and Advertisements, 35 and 36, Bedford-street, Strand, London, W.C.**

**We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.**

TELEGRAPHIC ADDRESS } "ENGINEERING," WESTRAND, LONDON.
TELEPHONE NUMBERS—3663 and 8596 GERRARD.

### S.S. "PERSIA" AND S.S. "MALOJA."

**The Publisher desires to notify subscribers to "ENGINEERING" in the East who did not receive their copies of "ENGINEERING" of the issues of December 17, 1915, and February 25, 1916, that they may have gone down with the mails in the S.S. "Persia" and S.S. "Maloja." A few copies are still in stock of each of these issues, and may be secured at the ordinary rates, plus postage.**


## CONTENTS.


| | PAGE |
|---|---|
| The Running of Boiler Plants and National Economy | 395 |
| Cross-Compound Winding-Engines for the Chislet Colliery, near Canterbury (*Illustrated*) | 397 |
| Some Effects of the Bulkhead Committee's Reports in Practice (*Illustrated*) | 398 |
| Water-Pressure Regulating Apparatus (*Illustrated*) | 402 |
| The late Mr. John Tweedy | 403 |
| Industrial Notes | 403 |
| Foreign Engineering Projects | 403 |
| The Royal Meteorological Society | 403 |
| Large-Boiler Locomotives | 405 |
| Genesis and Absorption of X Rays (*Illustrated*) | 406 |
| The Critical Speeds of Shafts | 407 |
| The Institution of Naval Architects | 407 |
| The late Erasmus Darwin Leavitt | 408 |
| Note | 408 |
| The Development of the Military Aeroplane (*Illus.*) | 409 |
| The Future of Ship Propulsion: Reduction Gears | 409 |
| "On the Whirling Speeds of Loaded Shafts" | 410 |
| Notes from the North | 410 |
| Notes from South Yorkshire | 411 |
| Notes from Cleveland and the Northern Counties | 411 |
| Notes from the South-West | 411 |
| Theory and Practice in the Filtration of Water (*Illustrated*) | 412 |


*With Four One-Page Plates of the CROSS-COMPOUND WINDING-ENGINES AT CHISLET COLLIERY, NEAR CANTERBURY.*

## NOTICES OF MEETINGS.

THE SOCIETY OF ENGINEERS (INCORPORATED).—Monday, May 1, at 5 p.m., at Caxton Hall, Westminster, S.W. A Conference on Engineering and Scientific Research will be opened by Dr. J. A. Fleming, M.A., D.Sc., F.R.S.

THE ROYAL SANITARY INSTITUTE.—Wednesday, May 3, at 5.30 p.m., at 90, Buckingham Palace-road, S.W. Lecture to the Institute, by Mr. Augustus Waller, M.D., F.R.S. (Director Physiological Laboratories, University of London), on "The Economics of Food Supply in War Time." Lieut.-Colonel Sir Shirley F. Murphy, F.R.C.S., R.A.M.C. (Vice-President), will take the chair.

THE INSTITUTE OF METALS.—Thursday, May 4, at 8.30 p.m., at the Institution of Electrical Engineers, Victoria Embankment, W.C. Sixth annual May lecture, by Professor W. H. Bragg, D.Sc., F.R.S. (Nobel Prizeman). Subject: "X Rays and Crystal Structure, with Special Reference to Certain Metals."

THE IRON AND STEEL INSTITUTE.—Thursday, May 4, at 10.30 a.m. General meeting of members. The Council will present their report for the year 1915. The Hon. Treasurer will present the statement of accounts for 1915. Scrutineers will be appointed for the examination of voting papers for election of new members of the Institute. The Acting-President will move the adoption of the proposed new bye-laws, as amended at the autumn meeting, for incorporation in the bye-laws of the Institute. The Acting-President (Mr. Arthur Cooper) will induct into the chair the President-Elect (Sir William Beardmore, Bart.). The Bessemer Gold Medal for 1916 will be presented to Mr. F. W. Harbord, F.I.C. The President will deliver his inaugural address. A selection of papers will be read and discussed (Nos. 5 and 1). Friday, May 5, at 10 a.m. General meeting of members. The award of grants from the Andrew Carnegie Research Fund in aid of research work will be announced. Papers Nos. 2, 4, 8, and 3 will be read and discussed. If time permits, other papers may be discussed at any of the sessions. The following list of papers is expected to be submitted for reading and discussion:—1. "Notes on the Theory of the Corrosion of Steel," by Mr. L. Aitchison. 2. "Notes on the Relations between the Cutting Efficiencies of Tool-Steels and their Brinell or Sclerscope Hardnesses," by Mr. J. O. Arnold, D.Met., F.R.S. 3. "A New Thermo-Electric Method of Studying Allotropic Changes in Iron or other Metals, by Mr. C. Benedicks, Ph.D. 4. "Initial Temperature and Critical Cooling Velocities of a Chromium Steel," by Mr. C. A. Edwards, D.Sc. 5. "The Influence of Carbon and Manganese upon the Corrosion of Iron and Steel," by Sir Robert Hadfield, D.Met., F.R.S., and J. N. Friend, D.Sc. 6. "Early Experiments on the Recalescence of Iron and Steel," by Mr. A. Mallock, F.R.S. 7. "A Few Experiments on the Hardness Testing of Mild Steel," by Mr. W. N. Thomas, B.Sc. 8. "Surface Tension Effects in the Intercrystalline Cement in Metals and the Elastic Limit," by Mr. F. C. Thompson, M.Met., B.Sc.


### NOTICE TO NON-SUBSCRIBERS.

**In view of the restrictions now imposed by the Government on the importation of paper, and of the consequent shortage of supplies, readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk. Owing to the scarcity of paper it will be impossible in future fully to provide for a chance demand for this Journal.**



# ENGINEERING.

*FRIDAY, APRIL 28, 1916.*


## LARGE-BOILER LOCOMOTIVES.

THE important part played by the boiler in modern locomotive design has frequently formed the subject for comment in these columns. In this country, owing to limitations from which we cannot get away, matters cannot be carried as far as, for instance, in the United States. Nevertheless, the trend of design of late years in both countries has perforce been the same. The fast timings with heavy loads, now common, make high average speeds essential. The days of short bursts of high speed are over. To maintain modern schedules speeds must be good up hill and down dale, and a good average is wisely considered preferable to sensational performances on favourable stretches on the run. In other words, the demand on the locomotive in what we may call "first-class service" is for high and sustained power. In passenger work loads and average speed are high. Of freight service the same is true, though in a variety of combinations ranging between "heavy" and "fast" freight service. In either case the locomotive must be capable of a large and well-sustained output, so that boiler capacity has come to be in a manner the leading feature of the high-power locomotive. It is, so to speak, as if the boiler claimed first attention, the running gear being subsequently brought up to the required state of development.

That, however, is not strictly the case, for we all know how interdependent are the various parts of a locomotive. The design of all must go hand in hand; yet, if we want maximum power, pervading and overshadowing all is the boiler question. What must, or what may, be done to secure the best boiler is of paramount importance. The saving of weight elsewhere may allow more weight to be put into the boiler. The better balance of parts may permit heavier axle-loads and a larger boiler. Or should another axle be adopted? But size alone is not everything. With size there must be correct proportioning; otherwise we shall be no better off. There have been well-known cases of big boilers crammed with tubes, and having exceptional heating surface, which have proved failures; and others with equally large surface, but so sluggish, owing to length of tube, that the expected capacity was never realised. In others, again, the importance of the fire-box and grate seems to have been sadly underrated, and everything staked on the tube surface. Maybe the failures are not so striking here owing to the tentative manner in which we have developed the large locomotive. In the United States, with more scope, the designer has been bolder, and lack of success, when it has occurred, has been the more noticeable, perhaps. Taking it all round, when it is considered how little real investigation work is possible in locomotive engineering without incurring immense expense, is it not greatly to the designers' credit that failures have been so few?

In this matter no system has taken more care to be sure of its ground than has the Pennsylvania Railroad. Fortunately situated in being powerful enough to be able to afford the expense of running the best organised test department in existence, it has threshed out the effect of changes step by step, with very important results upon the design of its locomotives. Under the supervision of Mr. J. T. Wallis, General Superintendent of Motive Power, the work carried on by Mr. C. D. Young, Engineer of Tests, at Altoona, has proved the value of thorough investigations, and its effect is seen as the designs are brought nearer and nearer to the ideal aimed at. Some time ago we dealt with the various changes which had resulted in the production of a very remarkable design of 4-4-2 type locomotive. This engine is more powerful than many of the 4-6-2 type. It is the outcome of testing-plant investigations, having a boiler which is an excellent compromise between activity and economy — which, while avoiding sluggishness and consequent restriction of output at the higher rates, still has sufficient surface to prevent waste of heat. Niceties of design such as these are hard to settle without some foundation to work on. One school advises the use of long tubes, so as to provide a reserve of heating surface for abnormal conditions; an economical boiler result, but one which cannot be forced to high capacity. Others prefer short tubes, giving an active, but wasteful, boiler. The desired compromise between these two seems to have been arrived at in this 4-4-2 locomotive, as the result of work on the testing plant, in a way which would have been impossible with road tests only to go upon. A very powerful engine has been produced, and is now in service on the easier divisions of the system. On the hilly divisions it gives place to the 4-6-2 class, the latest example of which bears marks of no less careful design, the result of sifting testing-plant information regarding a number of previous designs of the same general type.

This latest engine, be it noted, is not the largest 4-6-2 locomotive on the system, but it is at once the most powerful and the most economical of this type. Its superiority is due primarily to good boiler proportions. With practically the same grate area as the largest engine of the type, it has larger fire-box heating surface, but shorter tubes. The greater activity of the boiler is apparent, while the increase in fire-box surface probably largely accounts for the good transmission. The following proportions of this "K 4 s" class may therefore be of interest:—Ratio of heating surface to grate surface, 70.2 : 1; flue area of tubes to grate area, 0.12 : 1; fire-box surface to grate surface, 4.4 : 1; tube heating surface to fire-box heating surface, 11.0 : 1; ratio fire-box volume, in cubic feet, to grate surface, in square feet, 5.1 : 1. The grate area is 69.26 sq. ft. The boiler is fitted with a superheater, whose heating surface is included in the ratios above, the ratio of total heating surface to superheating surface being very nearly 4 : 1. This boiler has given a maximum evaporation of 65,400 lb. of water per hour, the highest rate of combustion reached being 171 lb. of coal per square foot of grate per hour.

With cylinders 27 in. by 28 in., and 80-in. driving-wheels, this locomotive can be maintained at over 60 miles per hour with a cut-off of more than 50 per cent., so ample is the boiler capacity. The maximum indicated horse-power developed on the plant was 3183.9, obtained with a cut-off of 65 per cent, and at a speed of 47.3 miles per hour. This

power works out at the rate of 1 indicated horse-power for every 97.1 lb. weight of the locomotive. The 4-4-2 engine referred to above works out at 1 indicated horse-power for every 96.5 lb. weight. There is thus practically no falling off in power with the heavier locomotives, as is sometimes contended. That they may also be designed to be economical is proved by the fact that at 1600 indicated horse-power this locomotive takes only 1.75 lb. of coal per indicated-horse-power hour, while up to 2600 indicated horse-power its coal rate is less than 2.5 lb., and at maximum power it is 3.25 lb. of coal per indicated-horse-power hour.

Advocates of standardisation will be interested to hear that this boiler has also been fitted to a new class of 2-8-2 engines. The practice of building standard boilers suited to several classes is well known over here, but this is the first time it has been attempted on the Pennsylvania Railroad. The results have proved excellent. Till lately, for road service, this system confined itself for freight work to heavy 2-8-0 or "Consolidation" locomotives. Heavy through train loads have now exceeded the limits of the 2-8-0 class. As we showed not long ago, the 2-8-2 type is the natural sequence, the extra weight being mostly put into the boiler. How this has been worked out in this case may be gathered from the following facts. The 2-8-2 engine is 25.7 per cent. heavier than its 2-8-0 predecessor, but is only 5.6 per cent. heavier on the driving-wheels. Compared with the old, the tube-heating surface has been increased 30.8 per cent., the fire-box heating surface 58.8 per cent., the superheater surface, 44.8 per cent., the total heating surface 37.1 per cent., and the grate area 26.5 per cent. With cylinders 27 in. by 30 in., driving-wheels 62 in. in diameter, and boiler pressure 205 lb. per sq. in., the tractive effort at starting (assuming 80 per cent. of the boiler pressure available) works out at 57,850 lb. The actual figure reached on the plant was 59,742 lb., thus more than justifying the use of 80 per cent. in this calculation. The boiler capacity has so far been increased over the former class that with cylinder volume enlarged 25 per cent. there is still ample steam at 30 miles per hour and 60 per cent. cut-off. The new engine can exert at 30 miles per hour a pull which the former type could only manage at 18.6 miles per hour. Evidently the new engine promises well either for heavy or fast freight service. Its highest recorded power was 2837 indicated horse-power at 31 miles per hour and 60 per cent. cut-off, while its coal rate runs out between 2.5 lb. to 4 lb. of coal (freight quality) per indicated-horse-power hour. On the weight-power basis it is 8 lb. per indicated horse-power to the good compared with the older and smaller class.

Satisfactory as this design has proved itself to be, some changes, it would seem, may still be made with advantage. This boiler is fitted with tubes 19 ft. long and Schmidt superheater elements running back to within 2 ft. of the fire-box tube-plate. Although the proportion of superheating to total heating surface is nearly 1 : 4, the superheat is comparatively low, while the pressure drop is considerable. Recent researches at Altoona all go to support the contention advanced in these columns in 1911,* that a good part of the return bend of these superheater elements does no good, and might with advantage be abolished. They also point to the desirability of keeping the steam in the hot zone as long as possible. In this particular boiler much higher superheat and a smaller pressure drop were secured by lengthening the elements 1 ft. towards the fire-box and cutting out half the return bends. We shall doubtless before long see a considerable modification of the common practice of running the return bends right out into the smoke-box. Perhaps, also, in time, some other modification may be possible so that the risk of parting with heat from the highly superheated steam to the gases in the flues near the front end will also be avoided.

Figures for exhaust-steam temperatures in these large engines show that often more than 80 deg. superheat may be found in the exhaust. That much of the heat thus going to waste is reclaimable is, we are glad to see, the subject of consideration on so important a system as the Pennsylvania Railroad. On a line where every subject is so systematically threshed out we may look for interesting developments in this direction.

* See ENGINEERING, vol. xciii., page 277.

## GENESIS AND ABSORPTION OF X RAYS.

SINCE 1907 scientists have been looking forward to the series of six lectures, and to the one discourse preceding the last of those lectures, which Sir J. J. Thomson, O.M., P.R.S., has been delivering before Easter in the Royal Institution, as Professor of Natural Philosophy to that Institution. The discourse of Friday, April 14, by Sir Joseph on "Genesis and Absorption of X Rays" may be said to fit into his six lectures on Radiation, the last of which we noticed in our issue of April 21, approaching the problem from other points of view, and also to link on to the discourse on "Slow Cathode Rays," which he gave a year ago.

Röntgen rays—which will come of age this autumn, by the way—Sir Joseph said in his discourse, were produced when cathode rays struck against matter, and their nature differed when the velocity of the cathode rays and the nature of the matter were changed. X rays were only a particular kind of light, and the study of their genesis and absorption had a particular interest also in this connection. As regards the emission of light, two cases might broadly be distinguished. The first was that of solid bodies becoming luminous like a lamp filament, whose light changed with the temperature; it first gave out a red glow, then yellow, and finally white light, and the length of the light waves emitted diminished continuously and without any jump—provided there were no chemical action—as the temperature rose. The second case, of gases or vapours, was altogether different; sodium vapour gave no light until the temperature reached a certain value; then the D lines flashed up, and when the temperature was further raised the D lines became more intense, but the wave-length of the radiation did not diminish until finally another spectrum made its appearance. To which class did X rays belong? Again, as to absorption of light, two classes might be distinguished: a general absorption or weakening of the light, and a special absorption of specific kinds of light. The question of absorption looked very simple in text-books. When sodium vapour absorbed the sodium light which fell on it from a hotter sodium flame, and which it itself emitted, that was not merely a case of absorption; absorption involved some transformation of energy, not an uninterrupted train of regular waves. To exemplify his meaning, Sir Joseph showed a rod, several feet long, horizontally supported, which was axially moved to and fro; a number of pendulums of different lengths were suspended from the rod. When the movement was slow, the pendulums more or less moved with the rod; as the rod was speeded up, some of the pendulums became wildly jerky in their movements; at still higher speeds

*Fig. 1.*

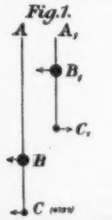
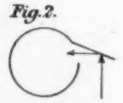



*Fig. 2.*



they oscillated quietly again. Further, in the pendulum A B C (Fig. 1), a heavy ball B and a light ball C were attached to the same string, A B being longer than B C; this pendulum oscillated as a whole. Then the string A B was shortened, $A_1 B_1$ being now shorter than $B_1 C_1$; the two balls then oscillated in opposite directions.

Such experiments had an important bearing on the consideration of the transmission of light at different periods; there might be a range in which light was not transmitted. When the electric and magnetic forces acted in certain directions, at right angles to one another, the direction of the propagation of the light, at right angles to both these directions, was fixed. But when these forces acted on a system which itself could produce an electric force, then a field of the opposite direction might be set up, the light would be sent back, and the substance would be impermeable or opaque to that light. Thus one understood that absorption depended upon frequency; yet it might appear independent of frequency for certain ranges. Exhibiting various absorption curves—*e.g.*, that of sodium light—Sir Joseph pointed out that the curve was flat in the infra-red and red, rose to a peak in the yellow, and then fell off rapidly; that meant that the absorption was the same for infra-red and red light, but increased enormously as the wave-length diminished in the yellow, and fell off rapidly beyond the yellow. When the curves for several substances emitting light of different periods were combined, the resulting curves showed peaks joined by more or less flat portions, in which change of frequency did not affect the absorption, whilst near the peaks any change made a great difference. Showing Kaye's curve for the absorption of Röntgen rays, Sir Joseph remarked that X rays exhibited these peculiarities of selective absorption in a striking way. The absorption in copper, *e.g.*, decreased in general as the rays became harder (of smaller wave-length); but when the rays became as penetrating as the characteristic rays of the absorbing medium (the K and L radiation of copper), the absorption increased radidly.

The particular region of Röntgen radiation, Sir Joseph continued, that he was interested in was that lying between visible light and the medical rays (so to speak), the little-explored region to which he had referred last year.* The difficulty about that region was that the waves were too short to be examined by the aid of gratings (useful for the study of visible light) and too long for making use of the spacings of the planes in which atoms were grouped in crystals (as in the X-ray study of crystal structure). He had thus either to determine the speeds of slow cathode rays, which, striking a target, would send out those long-wave Röntgen rays, or to determine the absorption of these latter rays. He had first used the former method with the aid of Coolidge tubes, Mr. Coolidge having kindly sent him a series of tungsten spirals. These spirals were heated by the current of a strong battery, and then gave out electrons, to which the desired velocity was imparted by the potential of the Coolidge tube. For this excitation by currents ranging from a few volts up to 5000 volts, he had first used storage cells, which were troublesome, however, and had then made use of one of the high-tension dynamos of Messrs. Evershed and Vignoles, which gave a constant voltage within 3 or 4 per cent. In the experiments the rays from a target passed down the neck of a glass vessel (silvered inside) to a second target, which emitted a radiation towards the silvered surface; that silver was charged up to a certain potential, however, to stop the rays. Now if the radiating body had been an ordinary solid (a filament), the voltage to be applied to the silver would have had to be increased continuously as the wave-length of the arriving rays diminished. But experimenting with rays from 12 volts up to about 1200 volts, he had found that they were all stopped by 8 or 10 volts, so that these rays were hardly Röntgen rays, and, in fact, they would scarcely be beyond the visible range in the ultra-violet.

To demonstrate that such a constancy of light emission was possible also under other circumstances, Sir Joseph bombarded the shell of some common mussel in a bulb with rays of about 10,000 volts; the shell gave out light, ordinary light, which hardly changed in appearance, when a little hydrogen was admitted into the bulb; this was done by heating a closed small palladium tube attached to the bulb by the Bunsen flame, the hydrogen of which passed through the hot palladium. The greater part of the light energy was not in the high-frequency rays in this case, but rather in the visible and ultra-violet spectrum.

Turning to the study of the absorption, Sir Joseph said that rays so nearly ultra-violet were very easily absorbed, and the exceedingly thin windows and films of celluloid [made by Mr. E. Everett, Sir Joseph's assistant, as mentioned last year] had proved very useful in these experiments. The character of the results had surprised him. Instead of observing a great increase of the penetrating power of the rays with increasing hardness of the rays, gold, *e.g.*, had given two ranges of constant absorption, separated by a sudden drop of absorption; starting with 200 volts, the absorption was rather high, but constant up to a certain value, then dropped, and remained constant again for higher voltage. Under the same conditions aluminium gave a curve which dropped near 200 volts to a small, constant value, whilst for ordinary—*i.e.*, much faster—X rays, aluminium showed a regular diminution in the ab-

* See ENGINEERING, vol. xcix., page 384, April 2, 1915.

sorption with increasing frequency. In other experiments absorbers of aluminium or of carbon were used with rays from targets of quartz, copper, silver, carbon, lead, aluminium, at voltages ranging from 1500 to 4500; the absorption remained in most cases almost constant throughout. With the aluminium absorber it was, further, the same practically for the various substances, the coefficient being about 2, whilst with the carbon absorber there was a small decrease of the absorption—from 2.8 to 1.7 in the case of copper, *e.g.* There were certain fluctuations, however. That aluminium absorbed less and less of the rays at really high frequency was shown by an experiment with a Coolidge tube, whose volts were raised from 30,000 to 100,000, and possibly to 200,000, which, of course, required special apparatus. Two screens, a very thin foil of tin and a piece of aluminium 2 mm. in thickness, held between the tube and the phosphorescent screen, finally became equally transparent, when the volts were raised sufficiently. In order to meet the objection that the influence of the secondary radiation from the windows had perhaps been predominant in his experiments with soft rays, Sir Joseph had changed the experimental conditions in various ways, and he then ascertained that the fluctuations above alluded to gave rise, with gold, silver, copper, aluminium and celluloid, to a decided drop in the absorption between 3000 and 3500 volts.

Another way of examining these peculiarities, Sir Joseph continued, was the following. In front of the window of a bulb containing some gas was hinged a plate of copper. The Röntgen-ray apparatus was so placed that the rays could not enter the bulb, but the cathode rays which they excited in the copper could enter (Fig. 2). The bulb was connected with a Zeleny electroscope. When soft rays struck the plate, no radiation entered, and the electroscope remained at rest; but when the rays were speeded up, to something like 100,000 volts in the experiment, the electroscope became restless. This electroscope, it will be remembered, consists of a vertical strip, in front of which a gold foil is suspended edgeways; the foil keeps on making small oscillations as long as the discharge continues, the rate of the oscillations depending upon the intensity of the current.

Concluding, Sir Joseph Thomson remarked that the stress of time had not allowed him to make measurements of the wave-lengths corresponding to the characteristic frequencies and absorptions. But the questions he had put in his introduction could be answered in a general way. The Röntgen radiation corresponded to the case of the discontinuous line spectrum of a vapour. Until the cathode rays had a certain velocity there was no X-ray emission; then rays of a certain wave-length appeared, and continued to be emitted as the volts were raised, until a second radiation appeared together with the first; with very swift rays then a third radiation came in, and so on. Only a small fraction of the energy went into the continuous spectrum. The cathode rays drove out electrons from the atoms, first the electrons near the surface; at higher speeds the rays penetrated more deeply, and the inner electrons were knocked out. The resulting spectrum was due to the return of the electrons to the atoms, and was in the main a line spectrum, superimposed, however, on a continuous spectrum of small energy. The lines could be determined not only in the ordinary region of the Röntgen rays, but also in the gap between the ultra-violet and the X rays proper. Radiations stopped by the thinnest film of celluloid, less than $\frac{1}{100,000}$ mm. in thickness, or able to penetrate through stout glass walls, were all of the same nature finally.

## THE CRITICAL SPEEDS OF SHAFTS.

In the interesting and valuable discussion to which Mr. W. Kerr's paper on "The Whirling Speeds of Loaded Shafts," recently published in our columns, has given rise, one point has, perhaps, failed to attract the attention it deserved. It appears to have been tacitly assumed throughout that the critical rate of revolution is independent of the deflection of the shaft. This assumption seems hardly justified, as to a first approximation it is the moment of momentum, rather than the rate of revolution, which remains constant when the shaft begins to vibrate. The following way of regarding this matter may be of interest. Let $N_c$ be the critical speed as determined in the usual way, and let N be the running speed of the shaft. Then if the shaft be disturbed whilst running, the rate at which it will *tend* to vibrate is given by the relation

$$n^2 = N_c^2 - N^2.$$

This formula corresponds to that given by Professor Morley, page 287 *ante*, but we have introduced the word "tend" advisedly. If

$$N = N_c \text{ we get } n = 0,$$

which is a known result. Similarly, if

$$N = 0, n = N_c,$$

another known result. Suppose, however,

$$N^2 = \frac{N_c^2}{2}.$$

Then we have

$$n^2 = \frac{N_c^2}{2} = N^2,$$

so that the frequency at which the shaft *tends* to vibrate is the same as the rate of revolution. Since a circular motion can be resolved into two transverse motions at right angles to one another, a resonance effect is certain to occur, and were there not some controlling factor, exceedingly dangerous vibrations should ensue at a speed equal to 0.71 of the critical speed as calculated in the usual way.

The centre of gravity of the rotating shaft would, in fact, describe a very elongated ellipse, the major axis of which would grow greater and greater at each succeeding revolution. It was just about at this ratio of the usual critical speed that the vibrations noted by Mr. Kerr occurred, and many builders of turbines have also noted serious disturbance at about this proportion of the true critical speed. That the vibration at this speed is in general relatively moderate shows that some damping factor must be at work, and we would suggest that the reason why the vibrations do not usually become actually alarming at this speed lies in the circumstance that the rotating wheel tends to preserve unaltered its angular momentum. Hence, if the vibration increases, the value of N automatically diminishes, and thus becomes less than the frequency of the revolving shaft. When, however, the wheel is very light, and is coupled up to a heavy rotor, the value of N may alter little with considerable variations in the deflection, and the vibration may be serious. It is reported that there was considerable difficulty in securing steady running with the 3000-horse-power single-stage steam-turbine erected at the Moabit station, Berlin, some twelve or thirteen years ago. This had a very light wheel coupled to a heavy rotor, and it seems possible that the cause of the trouble experienced was as indicated in the preceding paragraph.

The tendency of a revolving mass to retain unaltered its angular momentum would also seem to have a bearing on what occurs at the whirling speed as given by the usual formula. At this speed the value of $n$ is zero; the shaft therefore should not vibrate at all if N remained truly constant, but the deflection should steadily increase until fracture occurred. What actually happens would appear to be that as the shaft begins to take a large deflection, N automatically falls below the critical value, so as to maintain the constancy of the angular momentum. The deflection diminishes accordingly, to again increase as N rises again to the critical value. A vibration is then established in conditions in which the theory as usually set forth would seem to show that there should be none.

## THE INSTITUTION OF NAVAL ARCHITECTS.

(*Concluded from page 371.*)

### The Russo Rolling Tank.

On the afternoon of Thursday, the 13th inst., the proceedings were opened by a cinematograph demonstration of the Russo rolling tank. In attempting to make rolling experiments on models a difficulty arises from the fact that waves are reflected from the fixed ends of any tank used. The consequent interference of the direct and reflected waves makes the conditions of the surface in no way representative of deep-sea wave motions. The idea on which the tank devised by Colonel G. Russo, R.I.N., is based may be explained as follows:

Suppose a very flexible sheet to be suspended vertically in still water. If a wave motion arises, this vertical sheet will be deformed as the wave passes, oscillating to and fro, and interfering in no way with the propagation of the wave. This is the principle on which the Russo tank is based. The tank sides and ends are made of india-rubber, and by suitable mechanism a deformation is impressed on them, which is exactly the same as would be suffered by the hypothetical flexible sheet above referred to. The result is that the surface of the water reproduces exactly the motion of deep-sea waves. Tests of models can therefore be made in conditions in every way comparable with those experienced by the equivalent full-sized ship in the open sea.

At the conclusion of the demonstration, Sir John H. Biles said that he thought that the tank described itself by the motion photographs reproduced even more ably than the author had done in his paper.

Mr. A. Cannon, in discussing the results, said that the motion of the water in the tank demonstrated the soundness of the theory of trochoidal waves. By the correct phasing of the ends there was no reflex action giving rise to interferences such as occurred with solid-ended tanks. In other attempts to reproduce wave motion, as with the navipendulum, with which he had worked at Glasgow, it was difficult to eliminate undesirable conditions, although with a modified form of the instrument he had succeeded in reducing the resistances so that they were comparable with that corresponding to rolling in smooth water. All these difficulties were obviated by the Russo tank, which automatically reproduced the true natural conditions of wave propagation. This was a great advance, as hitherto his experience had been that 99 per cent. of the total time spent on a research was expended in getting ready and about 1 per cent. in getting out the actual figures. He looked forward accordingly with great interest to the results which would be obtained with the new tank.

### The "Empress of Ireland" Collision.

A paper entitled "Notes from a Collision Investigation," by Mr. John Reid, was, in the absence of the author, read by the Secretary. It was reproduced on page 387 of our last issue.

The discussion was opened by Colonel Saxton White, who said he did not propose to criticise the author's views. The paper was, he believed, the first brought before the Institution discussing the results of a collision. Everyone must regret that the Empress of Ireland had not proved the stronger of the two vessels at the point of impact. He questioned, however, whether any form of construction would have made it possible to resist such a blow successfully. According to the author, the Storstad struck the other vessel at an angle which, at the upper deck, lay between 40 deg. and 45 deg., whilst at the bottom of the stem it was not more than 35 deg. The dead weight of the colliding vessel was 14,000 to 15,000 tons, and the result must have been a foregone conclusion. Unfortunately, moreover, the striking ship was specially well adapted to act as a ram, being built on the Isherwood system of longitudinal framing. The author had stated that these frames were 24 in. apart; actually, however, they were much closer, being only 15 in. to 18 in. apart. The bow had, moreover, been specially strengthened for working in ice. Hence all factors were in favour of the striking ship. Looking at the section of the Empress of Ireland, it would be evident that the work done by the Storstad in passing through the side required no very great effort. The ship was hit between two frames, 16 ft. away from the nearest bulkhead. There was thus little to resist the cutting-in, except the decks, which, as it chanced, came very much in the same line as the corresponding decks of the Storstad. They were accordingly able to play a very important part in increasing the resistance of the stricken vessel. Whether the latter could have put up a better fight for it had she been built on the same system as the Storstad he could not say, but was inclined to think that she would probably have done better. The Storstad was the first of two vessels built by the speaker's firm on the Isherwood system, and he had had sent to him a model showing the damage done by the collision. Although this vessel of 14,000 to 15,000 tons was brought up standing, the deformation suffered did not extend back more than 8 ft. to 10 ft. from the stem. On the North Coast they saw all

sorts of national flags painted on neutral ships with the object of inducing belligerents to keep away. In view of the strength of the Isherwood system, a similar notification to other ships to keep clear might be of service to other vessels. From a naval architect's point of view the collision afforded a signal example of the strength of the longitudinal system of framing, and in newer vessels this was being made still heavier.

Mr. Hillyer, who followed, said he had been present at the inquiry, and had heard the whole of the evidence, including that given by the author of the paper. Mr. Reid had endeavoured to "reconstruct the crime," and to determine from this the circumstances of the collision. To the speaker's mind, however, the conclusions arrived at were fantastic and unnecessarily complicated. The hypothesis of a direct blow was put aside because the author asserted that the Empress of Ireland was not stationary at the moment of the collision. This assertion was not confirmed by the judgment of Lord Mersey and the assessors who investigated the case. Captain Kendall's evidence was that the Empress was stopped dead, and did not contribute to the force of the blow by her own motion. The Court merely held that he might possibly have been mistaken in believing that all way was off. This left the matter very doubtful, and did not justify the positive assertion made by the author. The latter's theory required that the engine-room bulkhead was not damaged. The engineers, however, testified that water was pouring through the bunker doors full bore within 20 seconds. Mr. Reid was asked in the court whether this direct evidence could be reconciled with his theories, and said "No." The speaker was accordingly greatly surprised at his again bringing forward his theories after this direct admission that they did not agree with the facts sworn in evidence. The theories were not accepted by Lord Mersey after consideration of all the evidence.

Sir John H. Biles said that in general it was not advisable to re-argue a case already decided in a court of law. Mr. Reid's paper would accordingly have been inadmissible were it not that he had brought forward some points not generally known. In any case the explanation of the manner in which he had made his case was interesting. This he had done from circumstantial evidence derived from a study of the condition of the one ship which had remained afloat. Such evidence was necessarily one-sided. In cases of collision, he would add, too much weight must not be given to observations made in previous cases. Each, in fact, stood by itself, and a conclusion right in nine cases might be wrong in the tenth. Colonel Saxon White's suggestion that other ships should keep clear of those built on the Isherwood system was interesting. There was, however, another possible alternative—viz., that the construction of boats so eminently adapted for ramming should not be allowed. Nevertheless we did learn from Colonel Saxon White that there was a gain in distributing frames longitudinally in place of transversely, as with a boat thus built the material was better distributed should she be hit. Even with this additional strength, however, he doubted whether many ships could survive such a blow as had sunk the Empress of Ireland.

### SHIPYARD CRANES.

A very important and instructive paper on "Shipyard Cranes of the Rotterdam Dockyard Company," by Mr. M. G. de Gelder, was read by Mr. W. J. Luke in the absence of the author.

In this paper, which we shall reprint in full in a later issue, the author described the lay-out of the yard of the Rotterdam Dockyard Company, which, although founded merely as a repairing yard in 1902, has now a greater output of tonnage than any other yard in Holland. Originally the ordinary derrick masts, fitted with electric winches, were used for hoisting material, wire-rope switchbacks being used for its transport. The capital cost was low, but as the size of the steamers built was constantly growing, quicker handling of material was necessary in order to obtain a large output with the limited number of hands available. The author designed a combination of travelling tower cantilever crane with a gantry between the berths, which has proved most satisfactory. The cranes can lift 3 tons at 72 ft. from the centre and 7½ tons at 29 ft. 6 in. radius. An ampere-meter in the attendant's cabin shows directly whether the weight being lifted is too great for the radius. The cranes are designed to continue at work in all weathers in which the wind is not strong enough to produce dangerous swinging of the material hoisted. The complete equipment for two berths capable of building 6000-ton steamers cost 5750*l*. An immense saving of time has resulted from the adoption of the cranes, amounting to one month out of the five formerly taken for building a 6000-ton steamer. Although the piece-work rates for riveting were not changed, the cost was reduced on account of the fact that the cranes allowed parts of bulkheads, girders, &c., to be riveted up hydraulically on the ground before being lifted into place.

Mr. Luke also opened the discussion. He said that it was one of the most interesting papers the Institution had had. He found that he had himself reached a stage in which he was not interested in $x$ and $y$ papers, nor in calculations, nor in the design of ships, but in the building of ships. The author had told them frankly what in his view was the best lay-out for a shipyard, and this view he had backed by the investment of his capital. It was an eye-opener to learn that the time of constructing a ship had been reduced from five months to four, and apparently without much effort. Another point was that these works, started in 1902, were now putting out more tonnage than any other in Holland. We would have to look to our laurels. The paper was most interesting and most valuable. The plan described was particularly applicable to a square yard, where one gantry could serve two berths. For diverging berths it was not quite so satisfactory. In one respect the use of cranes was perhaps less advantageous than the derrick system. When once laid down the crane system was fixed for all time, whilst derrick-poles could be readily shifted as occasion required.

Mr. Miller, who followed, said he had had the pleasure of seeing the cranes whilst in course of erection. Holland, being a very flat country, lent itself well to this system. The vessels were built on high blocks. The plan described did not lend itself so well to cases in which launching at an angle was necessary. We were accustomed to regard ourselves as pioneers in all shipbuilding matters, but in reality we were far astern. It was not possible here to do in the time the work recorded in the paper as being done in eighteen days, and many changes would be necessary to make the feat possible. The system adopted was of the simplest. There was neither a moulding-loft nor a plate-furnace at the site, but every shell-plate and frame arrived ready to go up into place. The De Gelder yard was an eye-opener in showing how quickly work could be done in a free country with free labour. His four visits to the yard made him feel that he knew nothing about shipbuilding, although he had been a shipbuilder for 35 years.

The meeting closed after the customary votes of thanks to the Society of Arts for the use of their rooms and to the President for his services in the chair.

## THE LATE ERASMUS DARWIN LEAVITT.

As announced in our paragraph on page 376 *ante*, and also in our report of the proceedings of the Institution of Mechanical Engineers at the general meeting held on the 14th inst. (see page 382 *ante*), Mr. Erasmus Darwin Leavitt, the eminent American engineer, died at Cambridge, Massachusetts, on March 11 last. Mr. Leavitt was born at Lowell, Mass., in October, 1836, and received his education at the public school of his native place. At the age of sixteen he was apprenticed at the Lowell machine-shop, where he remained for three years, serving afterwards one year with Messrs. Corliss and Nightingale. He then served as assistant foreman at the City Point Works, South Boston, where among his other duties he had charge of the construction of the engines of the United States flag-ship Hartford. For two years, from 1859 to 1861, he acted as head draughtsman with Messrs. Thurston, Gardner and Co., Providence, R.I., a post which he left in the latter year to enter the United States Navy, where he remained until 1867, serving during the Civil War. A part of his service with the Navy was spent in constructive work and as an instructor in steam engineering at the Naval Academy, Annapolis.

On leaving the Navy in 1867, Mr. Leavitt established a private consulting mechanical engineering practice, and, two years later, a simple condensing engine, having a steamboat walking beam and cam valve-gear which he designed, was built by Messrs. Harrison Loring, City Point Works, Boston, for the Plymouth Cordage Company. He remained consulting engineer for this latter company until he was compelled to resign, a short time ago, owing to ill-health. Among the installations designed by Mr. Leavitt, we may mention the pumping-engines at Lynn, Mass., which established his reputation as an engineer, and similar engines for the Lawrence, Mass., Water Works. In 1874 he was appointed consulting and mechanical engineer of the Calumet and Hecla Mining Company, a position which he held for a period of thirty years. In this latter capacity he designed a large number of pumping-engines, air-compressors, and other plant. He improved the company's steam stamps, ensuring thereby more rapid work and an important saving.

In 1881 and 1882 (see vol. xxxii., pages 163, 166, and 184; and vol. xxxiii., pages 290 and 291) we gave illustrated descriptions of some of the engines designed by Mr. Leavitt for the Calumet and Hecla Mining Company, one of these being a compound hoisting-engine, constructed by the I. P. Morris Company, Philadelphia. This particular engine was the fourth of a series designed by Mr. Leavitt and built by the same company. The first was built in 1874 and the second in 1876, both being used for pumping work. The third, completed in 1877, operated four hoisting-drums. In designing the fourth engine the economical advantages of high pressure and high piston speed were carefully taken into consideration; 135 lb. per sq. in. was adopted for the former and 720 ft. per minute for the latter. Mr. Leavitt was among the first engineers to adopt a high steam pressure for stationary engines, and up to the year 1886 he worked to that of 135 lb. as a standard. In that year, however, he started the design of triple-expansion engines on the basis of a pressure of 185 lb. per sq. in., and built a large number of these engines also.

Mr. Leavitt also acted for many years as consulting engineer for Messrs. Henry R. Worthington, the Bethlehem Steel Company, and the Dickson Manufacturing Company, for whom he designed pumping-engines for various duties, including the operation of forging-presses. He designed the first engines used for the cable railway of the Brooklyn Bridge; a complete engine and machinery plant for the Callao Mining Company, Venezuela; large pumping engines for the City of Boston sewage, for the Louisville Water Works, and the water works of other American cities.

Mr. Leavitt was one of the founders of the American Society of Mechanical Engineers (1880), acting as Vice-President in 1881-82, and as President in 1883. He was made an honorary member of that institution in January, 1915. He received, in 1884, the degree of Doctor of Engineering from the Stevens Institute of Technology. He became a member of our Institution of Mechanical Engineers in 1883, and was made an honorary member of that body on February 18 last. Until quite recently he was also a member of the Institution of Civil Engineers, having been elected in 1886. He was also a member of numerous other American and British societies and institutions. Throughout his career he was an earnest advocate for advanced practice, and he undoubtedly exercised a very strong influence on the development of steam engineering in America.

## NOTE.

### PREPARING PURE IRON AND IRON ALLOYS.

IN recognition of the fact that most, if not all, of the determinations of the iron-carbon diagram were not made with materials which could fairly be called pure to start with, and that the operations introduced further impurities into the iron, the Bureau of Standards has recently studied the preparation of pure iron and its alloys, and has met with quite the expected amount of difficulties. An account of the research so far carried out by J. R. Cain, E. Schramm and H. E. Cleaves, which gave an iron of 99.96 per cent., and carbon alloys of corresponding purity, has appeared in the March issue of the *Journal of Industrial and Engineering Chemistry*. The iron was prepared electrolytically by dissolving anodes of an ingot iron (0.016 per cent. of C, 0.022 S, 0.001 P, 0.029 Mn, 0.002 Si, 0.15 Cu) in hydrochloric acid to form a 23 per cent. solution of $FeCl_2$; the anodes were placed in porous clay cups, which were later, in the electrolytic tank substituted for

single cells, replaced by a cement of alundum and Ottawa sand. The air was excluded during the electrolysis; but a slight oxidation, rendering the solution turbid, could not be prevented, and when a carbon dioxide atmosphere was used, carbon entered into the iron. Anyhow, good iron deposits more than 7 mm. in thickness could not be obtained, and the iron contained hydrogen and some chloride, and was hard, brittle, and liable to rapid rusting; all these troubles are well known. Heated to 600 deg. or 800 deg. Cent. the iron lost its hydrogen and did not rust so much; it contained up to 0.035 per cent. of impurities (about 0.004 C, 0.006 Si, as much S and Cu, and 0.01 of nickel and cobalt together). But the 15 kg. of electrolytic iron had to be fused, and it proved exceedingly difficult to avoid contamination by gases and by contact with the furnace and crucible materials. These difficulties, it must be understood, are much greater in the laboratory than in practice. The fusion was effected in gas furnaces, Arsem vacuum and Helberger furnaces (both electric) and electric granulated resistor furnaces. The crucibles were another source of great trouble. Clay crucibles were quite useless in gas-furnaces, as iron oxide and slag were formed; alundum furnaces did not prove much better in this respect, and silicon was introduced into the iron even in the reducing atmosphere of the electric furnaces. Commercially pure magnesia was not free from silica either. Finally, a Grecian magnesite (3.5 per cent. of silica) was dissolved in acetic acid—dissolution in hydrochloric acid and precipitation with ammonium carbonate failed—the solution siphoned off, evaporated, and the dry salt calcined by letting the flame of a Teclu burner play upon it; this treatment introduced some carbon, and left a little iron in it; but the subsequent calcination at about 1600 deg. Cent. in a gas furnace was satisfactory. For this purpose balls of magnesia, moistened with water, were placed in plumbago crucibles lined with alundum or Acheson graphite; air had to be blown through the covered furnace after shutting off the gas, lest sulphur be taken up by the magnesia. Crucibles were made out of this magnesia (0.025 per cent. of $SiO_2$) under a pressure of 5000 lb. or 10,000 lb. per sq. in.; though they had generally to be broken to remove the iron or alloy fused in them, they seemed to be the best crucible available. The ingots, of about 100 grammes, were full of blow-holes even in the reducing atmosphere (of CO). To obtain sound ingots and to ensure that a definite quantity of carbon was taken up, the ingots were hence cut up with the saw, and the small lumps, mixed with the required carbon, remelted in the Arsem furnace at a pressure of 0.2 mm., the operation being watched through the window. As regards silicon, it was found that a temperature above 1600 deg. Cent. greatly favours its absorption by the iron. Manganese and phosphorus, and, with due precaution, sulphur, caused no trouble. About 0.005 per cent. of copper and the original 0.01 per cent. of nickel and cobalt (together) persisted in the iron. Magnesium was not found in the final iron, except in one case when the temperature of the magnesia crucible had exceeded 1700 deg. Cent. Oxygen was not altogether absent, but suitable analyses could not be made at the Bureau. In one instance J. A. Aupperle found 0.03 per cent. of oxygen. The spectroscopic tests conducted by K. Burns confirmed the analytical results.

## THE DEVELOPMENT OF THE MILITARY AEROPLANE.

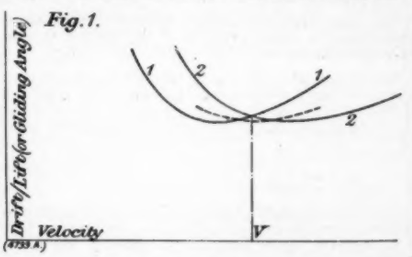
TO THE EDITOR OF ENGINEERING.

SIR,—I regret that, owing to pressure of work, I have been unable to reply at an earlier date to the letter of Mr. Jose Weiss criticising my recent article.

I, of course, agree that the gliding angle or resistance coefficient is a criterion of whether or not a glider or machine is correctly designed. It may be admitted that for the aerofoil the coefficient of resistance of minimum value is slightly less for a big machine than for a small one. This difference, according to the best experimental result, is very small. For example, if for some stated flight velocity the best possible for a 10-ton machine were a 4 per cent. resistance coefficient, the best result possible for a 1-ton machine, or even for a ½-ton machine, would be considerably under 5 per cent. I say *considerably under* advisedly, for I believe the difference would not be measurable by any known means. My own 1894 model (40-in. span, 1½-lb. lift) has shown a coefficient slightly less than 6 per cent. as tested, and other models of more usual aspect ratio have shown nearly as good a figure.

Now the graph giving the best gliding angle in terms of velocity is theoretically of the form given in Fig. 1, and in practice, though differing somewhat from this form, it is of the same character, so that the velocity of any given aerofoil may vary considerably around the minimum without measurably affecting the gliding angle. Conversely, the loading on an aerofoil may vary considerably in the neighbourhood of its value of least resistance without measurably affecting the resistance coefficient. In other words, two different loadings may give graphs 1 and 2 in the figure, or other different loadings anywhere between 1 and 2, and at velocity = V, which we will take to be our standard velocity, their resistance coefficients will be measurably the same. The result of this is that any two experimental gliders may be designed, both giving (within the limits of measurement) equally good gliding angles, and,

*Fig. 1.*




in fact, giving (within the limits of measurement) the least possible gliding angle, and yet they may differ widely as to loading. Hence for any individual experiments conducted within narrow limits of size, say in the ratio of 10 to 1 or less, it would be easy to obtain a totally wrong law of variation, and any conclusions based on the performance of successful gliding models (within a moderate variation of weight), unless the investigation is very thorough and rigorous, will be open to suspicion, and may be very wide of the truth; such determinations certainly cannot form the basis of sound and logical deduction.

I contend that the experiments on which Mr. Weiss bases his objections are founded on such a fallacy. With a narrow field of observation—*i.e.*, moderate weight variation—actual graphs should be plotted.

My own experiments and data comprise a very wide field of observation. The smallest model on which I have experimented, or from which I have data, is one of only 1 grain in weight, the largest an actual full-scale machine. I admit the said smallest model was not made the basis of many trials or experiments, so I will take as my smallest properly investigated model that of "one-quarter gramme" weight (§ 73, vol. ii., "Aerial Flight"), and the total range of weight thus compassed is, roughly, 1 to 4,000,000, and there are numerous confirmatory checks in between these two limits, including models of 4 grammes, 12 grammes, 1¼ lb. In addition to these checks there is a mass of matter in the reports of the Advisory Committee for Aeronautics, which also may be included in the sum and total of evidence. On the whole these cases are found to conform closely to the law that if $s$ be the span in feet, and V the velocity in feet per second, the expression $\frac{s^2 \times V^3}{10{,}000} = W$ is never far from the truth where W = the weight sustained in pounds under the conditions of least resistance. This expression may be otherwise represented by saying that if the span be taken in units of 10 ft., and the velocity in units of 10 ft. per second, the weight sustained in pounds under the conditions of least gliding is always in the region of $s^2 \times V^3$.

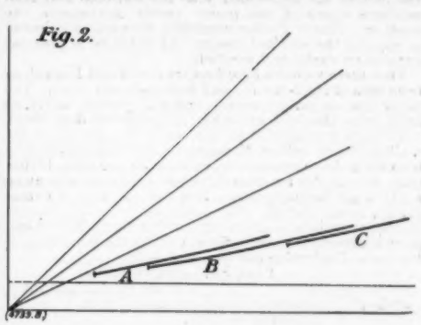
Thus, according to this equation, my "quarter-gramme" model should have weighed 0.0005 lb. Its actual weight was 0.00054 lb. Applying this to a monoplane of 50 ft. span and 90 ft. per second, we have 2050 lb. as the calculated load, which accords closely with experience. Actually such a full-size machine should be loaded more heavily, because, owing to considerations of wing-weight, the designer should sacrifice a minute difference in aerofoil resistance in order to save undue aerofoil weight; this in accordance with the well-known principles. (Set forth in vol. i. of my "Aerial Flight," §§ 171 and 194, *et seq.*) The equivalent of a 50-ft. span monoplane would be a biplane of about 40-ft. span.* This corresponds roughly to the BE 2C. machine of the Royal Aircraft Factory, in which the official gross weight is slightly under 1 ton.

I think that the foregoing facts are more than sufficient to refute Mr. Weiss's contention that the *load-span* law given by me is incorrect. If any further evidence is required, I would refer Mr. Weiss to the mass of work which has been done at the National Physical Laboratory at the instance of the Advisory Committee for Aeronautics in model aerofoil determinations, and which has been applied to full scale construction. *For a given aspect ratio*, the law may be otherwise expressed, that the pressure per square foot appropriate to least gliding (as concerns the aerofoil) is constant for a given velocity, and this is as set forth on the basis of theoretical investigation in my "Aerodynamics,"† and tabulated in §§ 185 and 186.

Finally, I will return to the details of Mr. Weiss's objection. Mr. Weiss states that the law of proportion which I have given above, and which is to-day regarded as generally established by experiment, is not in accordance with fact. He says that anyone who has any experience with gliders knows that a 5-ft. model, weighing 31 lb., glides very much like a brick. Now, according to the expression I have given, a model of 5-ft. span to carry 31 lb. in the region of its least gliding angle would require a velocity of 120 ft. per second, say, 80 miles an hour; if a biplane, for the same span, about 60 miles an hour. These are the same velocities as would have to be flown by a model of 40 ft. span and 2000 lb. weight, according to whether of monoplane or biplane design. The latter figure is, in fact, the approximate figure, weight and velocity, of the BE 2 C machine. If Mr. Weiss will make a model such as he suggests, and launch it by a catapult at the flight velocity stated, he will find there is nothing resembling the falling of a brick in its behaviour.

With regard to the letter signed by "Aeroplane Designer-Constructor" in your issue of March 31, I shall be quite prepared to answer and deal with this letter in detail if your correspondent will have the courage to publish his own name. I have never written under a *nom de plume* myself, and I feel that I am entitled to decline a correspondence with a person so disguised. I will say this much, however, that the remarks of your correspondent "Aeroplane Designer-Constructor" are mainly based upon his own rather distorted interpretation of my article. I think I can, perhaps, make the position clearer, and meet one of the objections which your correspondent raises by pointing out that the theory of least weight as given in my article only applies so long as the assumed premises are not violated. If, for example, some alteration be made in the method of construction of the aeroplane or wing members, or in the distribution of the load, the result will inevitably be that the curve of wing weight will have a different constant, and thus if three or four alternative methods of construction or design are available, the designer in laying out a diagram such as Figs. 3, 4 or 5 in the original article will have the choice of a number of different curves, A, B, C, &c., as suggested in Fig. 2, below. Usually, as a matter of engineer

*Fig. 2.*




ing practice, each type of construction will have limits to its applicability, just as in bridge construction a plank may be used and is appropriate for crossing a stream, a trussed girder for carrying a railway over a roadway or river span, and a cantilever construction for an estuary such as is spanned by the Forth Bridge. The rough-and-ready rule given by me both in *Land and Water* and in the article in your issue of March 3—namely, that in the design of a machine, whatever kind of aerofoil be adopted, the wing structure should not weigh more than twice the military load—applies, however, equally for any of these curves. Thus, if the designer, by his skill in distributing weight or in employing material, can reduce his wing weight, the size of the machine which may be designed for the given military load immediately goes up automatically to a higher figure.

I will quote and answer one sample criticism of your anonymous correspondent. He says:—"Were this dictum accepted" (concerning load capacity and range of flight), "there would practically be an end to progress in this direction." There is not the smallest ground in my articles quoted for any such assertion. I should be the last to attempt to prevent progress (or legitimate effort to progress) in any branch of engineering; I know, however, from experience that the thing which is most fatal to true progress is ill-considered or premature development without a sufficient attention to the underlying principles; metaphorically speaking, the building of a heavy structure on an insufficient foundation: the collapse of the superstructure may delay progress for decades.

I remain, yours truly,

April 15, 1916. F. W. LANCHESTER.

* Compare "Two Papers," 1915, Institution of Aeronautical Engineers, § 37.

† "Aerial Flight," vol. i. Constable and Co., 1907.

## THE FUTURE OF SHIP PROPULSION: REDUCTION GEARS.

TO THE EDITOR OF ENGINEERING.

SIR,—Mr. Dornan's paper on ship propulsion well deserves the extended notice you gave it in your excellent editorial of February 3, and I hope that many naval architects will thereby be led to study it. I wish to draw attention to one point only in the notice you kindly take of my contribution to the discussion. I have reason to think that engineers who have considered the use of the floating frame usually believe that it was introduced to annul in some degree the effect of bad tooth-cutting, and this is confirmed by your remarks. That such an opinion should be formed has always been a matter of surprise to me, for in the article in Engi-

NEERING, of September 17, 1909, page 377, where the principal function of the floating frame is set forth, errors of tooth-cutting are not once referred to. In an extended article on "Reduction Gears" which I have written, and which I hope will soon appear in ENGINEERING, I treat this question at some length, and show that by no practicable mechanical device can we hope nearly to annul the effect of such errors. No doubt the freedom of the floating frame eases up the induced stresses somewhat, and this is clearly indicated by the decreased noise of floating-frame over rigid-bearing gears, especially near full load; but though this was anticipated, it was not the object of the invention. The teeth *must be* cut with almost perfect accuracy. A high-class gear-cutting machine will do this, and the minute residual errors tend to disappear during the working of the gear if it is never overstressed.

The object of the floating frame was to annul the effect of errors of alignment of the pinion and gear axes. This is the insuperable difficulty with gears having rigid bearings. Calculation of the great rigidity of the teeth readily shows that, even in large gears, an error of alignment of $\frac{1}{1000}$ in. will lead to serious reduction of the length of tooth contacts, and, consequently, to more than proportionate rise of the maximum stresses, as the intensity of pressure at the reduced contacts is now very unevenly distributed. Even if properly set at first, sensible errors of alignment are sure to occur in the life of the gear, from various causes. As shown in the two articles above referred to, this difficulty is *entirely* avoided by the introduction of the floating frame, since no sensible disturbance of the tooth pressures is induced by misalignment within limits of errors of alignment which should ever occur in practice.

The variable load on the gear also introduces a variable torsional yield of the pinion, with corresponding errors in the helical angles of the gears. These errors are not unimportant. It is shown in the paper to which I have referred above that the floating frame corrects from one-half to two-thirds of this error; and also that it has some advantage over the rigid-bearing gear where the helices are so handed that the torsional and temperature errors of the pinion partly compensate one another. These two characteristics were not anticipated in making the original design, but came as a pleasant surprise on studying it carefully.

That these valuable functions are performed I can show from data of rigid-bearing and floating-frame gears. The latter bear, in daily operation and with perfect safety, at least twice the load at which, as published data show, rigid-bearing gears are usually run. The pinions of the United States collier Neptune on her endurance trial bore an average pressure more than 30 per cent. higher still—that is, not far from three times the usual operating load of rigid-bearing gears. Since we can thus maintain perfect tooth contact with certainty under all circumstances, there is increased safety, and a much lighter and more compact gear can be fitted; or, for the same weight, the ratio of reduction can be raised.

I am, Sir, yours truly,

JOHN H. MACALPINE.

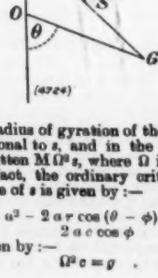
5845, Phillips-avenue, Pittsburg, Pa., U.S.A.
March 22, 1916.

## "ON THE WHIRLING SPEEDS OF LOADED SHAFTS."

TO THE EDITOR OF ENGINEERING.

SIR,—Mr. Kerr, in his recent discussion of the above matter, bids us to revise our ideas on the subject as far as concerns horizontal shafts. Close investigation, however, does not appear to substantiate the claim made, for whilst there is some tendency to oscillation arising from gravity, its effect is altogether negligible in practical cases, and, moreover, its critical speed is not that suggested by Mr. Kerr.

Taking the simplest case, that of a single disc of mass M at the centre of a light shaft, let B, in the figure, be the line of bearings, which is assumed to be also the centre of the shaft when unstrained; let O be the centre of the shaft at rest, so that O B (= $e$) is the sag due to the weight of the disc; let S be the centre of the shaft in general, and G the centre of gravity of the disc; let S G = $a$, a constant, O G = $r$, B S = $z$; let the angle between O G and the vertical B O be $\theta$, and that between S G and B O




$\phi$; let $k$ be the radius of gyration of the disc. The elastic force is proportional to $z$, and in the direction S B; its value may be written M $\Omega^2 z$, where $\Omega$ is an angular velocity, being, in fact, the ordinary critical speed of the shaft. The value of $z$ is given by:—

$$z^2 = e^2 + r^2 + a^2 - 2\,a\,r\cos(\theta - \phi) + 2\,e\,r\cos\theta - 2\,a\,e\cos\phi \quad . \quad . \quad . \quad (1)$$

The sag in given by:—

$$\Omega^2 e = g \quad . \quad . \quad . \quad . \quad (2)$$

The kinetic energy is given by:—

$$T = \frac{M}{2}\left\{\dot{r}^2 + r^2\dot{\theta}^2 + k^2\dot{\phi}^2\right\} \quad . \quad . \quad (3)$$

The potential energy is given by:—

$$V = \frac{M\Omega^2}{2}z^2 - M\,g\,r\cos\theta$$

$$= \frac{M\Omega^2}{2}\left\{e^2 + r^2 + a^2 - 2\,a\,r\cos(\theta - \phi) - 2\,a\,e\cos\phi\right\} \quad (4)$$

The equations of motion are accordingly:—

$$\ddot{r} - r\dot{\theta}^2 + \Omega^2[r - a\cos(\theta - \phi)] = 0 \quad . \quad . \quad (5)$$

$$r\ddot{\theta} + 2\dot{r}\dot{\theta} + \Omega^2 a\sin(\theta - \phi) = 0 \quad . \quad . \quad . \quad (6)$$

$$k^2\ddot{\phi} - \Omega^2 a\,r\sin(\theta - \phi) + \Omega^2 a\,e\sin\phi = 0 \quad . \quad (7)$$

The appropriate approximate solution of these equations when the angular velocity of the shaft is $\omega$ is as follows (neglecting the complementary function):—

$$r = \frac{\Omega^2}{\Omega^2 - \omega^2}a\left[1 + 2\,\frac{a\,e}{k^2}\,\frac{\Omega^2 - \omega^2}{\Omega^2 - 4\,\omega^2}\cos\omega t\right] \quad (8)$$

$$\theta = \omega t + \frac{a\,e}{k^2}\,\frac{(\Omega^2 - \omega^2)(\Omega^2 - 2\,\omega^2)}{\omega^2(\Omega^2 - 4\,\omega^2)}\sin\omega t \quad (9)$$

$$\phi = \omega t + \frac{a\,r}{k^2}\,\frac{\Omega^2}{\omega^2}\sin\omega t \quad . \quad . \quad . \quad (10)$$

There is accordingly a small forced oscillation ascribable to gravity, and its critical speed corresponds to $\omega = \frac{1}{2}\Omega$; it is, however, quite incapable of causing trouble in general.

In the case of a turbo-generator, for instance, the constants may have some such values as the following:—$a = 0.005''$, $e = 0.02''$, $k = 15''$, whence $ae/k^2 = 0.45 \times 10^{-6}$; the deviation from steady motion is accordingly inappreciable. To put the matter in another way, if the speed be kept exactly at $\frac{1}{2}\Omega$, the proportional deviation from the steady value of $r$, in this ideal case, becomes in time $t$:—

$$\frac{3}{8}\,\frac{ae}{k^2}\,\Omega t\,\sin\frac{\Omega}{2}t.$$

With the above figures, $\Omega = 140$ (equation 2), and the amplitude of the deviation is:—

$$\frac{3}{8} \times 0.45 \times 10^{-6} \times 140\,t.$$

Thus it requires about 7 minutes for the amplitude of the deviation to increase by 1 per cent. of the steady deflection.

Yours faithfully,

Rugby, April 6, 1916. F. W. CARTER.

ANTIMONY.—Antimony, says the *Moniteur Scientifique*, has been found at La Lucette, on the Oued Rummel, in the district of Constantine, of the French Province of Algiers. The ore is $Sb_2O_4$ and contains some sulphur; it is treated at Langeac, in the French Department of Haute-Loire, and yields regulus and antimonious lead with 91 per cent. of lead. The ore is dealt with mixed with the produce of Tunis mines and with industrial residues. Antimonious lead is also manufactured in other French establishments with another Algerian ore, taken at Hammam N'bail, also in the district of Constantine; this is an antimonite of iron containing up to 40 per cent. of antimony, also lead and zinc.

AMERICAN IRON ORE.—The shipments of Lake Superior iron ore last year were 47,272,751 tons, as compared with 32,729,726 tons in 1914, showing an increase of 14,543,025 tons, or 44.43 per cent. Last year's aggregate of 47,272,751 tons was made up as follows:—Marquette, 4,105,378 tons; Menominee, 4,982,626 tons; Gogebic, 5,477,767 tons; Vermilion, 1,733,595 tons; Mesaba, 29,756,689 tons; Cuyuna, 1,136,113 tons; and miscellaneous, 80,583 tons. While last year's shipments showed a large increase as compared with those of 1914, they were still smaller than those in 1913 and 1912, in which years 49,947,116 tons and 48,221,546 tons were despatched. Last year's iron imports into the United States were 1,341,281 tons, as compared with 1,350,588 tons in 1914, and 2,594,770 tons in 1913. The exports were:—1915, 708,641 tons; 1914, 553,618 tons; and 1913, 1,042,151 tons.

LIABILITY OF MANUFACTURERS. — The *Engineering Record*, New York, states that the purchaser of a motor-car was seriously injured as the result of the collapse of one of the wheels of the car after it had been in use for a year. The manufacturer resisted a suit for damages on the ground that he was not the maker of the wheels, but had bought them from a responsible maker, and used ordinary caution to ascertain that they were sound. It was shown that the collapse of the wheel was due to defective wood. The Court of Appeal held that the manufacturer "was responsible for the finished product," and could not shift the responsibility. The decision places squarely upon every manufacturer of any "finished product" full responsibility for injuries that may result from defects in any part of such a product. The Court specifically said that a manufacturer is not at liberty to put the finished product on the market without making such tests as will prove the absence or presence of such defects as might result in injuries through ordinary use. It is clear, adds our contemporary, that we have here a new rule of law, and one that may make serious trouble for a manufacturer who proceeds upon the old theory that he is not responsible for injuries resulting from defective parts of assembled machines or equipment.

## NOTES FROM THE NORTH.

GLASGOW, Wednesday.

*Glasgow Pig-Iron Market.*—Neither on Wednesday nor Thursday of last week was any business attempted in the pig-iron warrant market, there being no declared buyers or sellers on either day, a fact most probably due to the near approach of the Easter holiday. The market remained closed from Thursday to Tuesday morning, but again no business was recorded, complete idleness prevailing, with the settlement price at 87s. per ton. Similar conditions were noted again this morning, but the settlement price dropped to 82s. 6d.

*Scotch Steel Trade.*—While the drastic measure as originally framed by the Ministry of Munitions, fixing the maximum prices of all manufactured and semi-manufactured steel material, is not to come into force until May 1, there is already a considerably increased activity noted in all steel-making establishments in the West of Scotland, and manufacturers are doing their utmost to get as much as possible shipped before that date. By this action, and by prohibiting export, Government is obtaining a very full control of all works employed, either directly or indirectly, in the production of munitions and war material of every description, which ought now to be available at more reasonable rates. It will mean, too, that for the duration of the war Government orders generally will monopolise the entire output of the works under control. The greatest activity prevails everywhere in order to get as much finished material shipped before the new regulations come into force, as by far the larger proportion of this will come under licence on May 1. Unfortunately, the holiday has fallen at an inopportune time, and has therefore upset the calculations of those steel-makers who had quantities of material ready for despatch. Export prices, still being free, are gradually stiffening, while, of course, the rates for home consumption are rigidly fixed meantime. Boiler-plates may be anything from 14*l.* 10s. per ton upwards; ship-plates, 13*l.* 10s. to 13*l.* 15s.; and angles, 13*l.* 15s. or 14*l.*—all less the usual 2½ per cent. discount.

*Malleable-Iron Trade.*—A large volume of work is being put through by malleable-iron makers, who are still busily employed with the orders in hand, the only drawback being the continued scarcity of labour. Were it possible to procure the services of more skilled puddlers, the present output could be very materially increased, because, as it is, quite a number of furnaces are standing idle at the moment. "Crown" bars for home delivery are still quoted at 13*l.* 15s. per ton, less 5 per cent., and up to 14*l.* for export.

*Scotch Pig-Iron.*—The trade in Scotch pig-iron of all grades is extremely brisk, makers finding a ready market for all their output. Much inconvenience is being caused by the restrictions imposed by the recent Order in Council, for the postponement of its coming into force until May 1 has again been rescinded. It is expected that the fixing of prices will seriously affect the English sales of Scotch pig-iron, the heavy cost of the carriage, added to the already increased rates, being considered a serious deterrent to much business with Midland consumers. There is just a chance that some further alteration in the Order may yet take place, as makers feel that the shipment of pig-iron should be on a similar level to that of steel. At the moment, unless previously pre-entered or shipped under special Government licence, the export of pig-iron cannot take place. Prices have again gone up, the current rates for makers' (No. 1) iron being as follow:—Clyde, Calder, Summerlee, and Langloan, 130s. per ton; Gartsherrie, 131s. 6d. (all shipped at Glasgow); Eglinton, 126s. 6d., and Glengarnock, 130s. (both at Ardrossan); Dalmellington, 125s. (at Ayr); and Shotts, 130s. (at Leith).

*Technical Colleges and Munitions.*—In answer to the demand made recently, thirty-nine lathes are now in use at the Royal Technical College for the training of munition workers to be employed, after a short course of instruction, in shell-making at some of the local Government-controlled establishments. Women are also being trained as oxy-acetylene welders, and all those at present under instruction have already been engaged by a local firm employed in the manufacture of trench-bombs.

*Large Liner Launched at Dundee.*—On Wednesday last there was launched from the yard of the Caledon Shipbuilding and Engineering Company the largest vessel yet built at Dundee. The Troilus, a passenger and cargo steamer, built to the order of the Ocean Steamship Company, Liverpool, is 454 ft. in length, 56 ft. in breadth, 35 ft. 2 in. in depth, and of about 7400 tons gross, with triple-expansion engines of 572 nominal horse-power, supplied by the builders.

"WATER-FINDERS" IN QUEENSLAND.—The Queensland Lands Department employs two officers officially designated "water-finders." One works with the automatic finder, and the other with the old-fashioned twig, one checking the other. A remarkable demand for their services has set in. In fact, it is impossible to meet all the requests in a given time. A report has just been submitted to the Lands Department on the result of their operations in the Shire of Murgon, where they conjointly selected a number of sites for wells. Seven cases were quoted. In one water to the amount of 600 gallons per hour was struck, the pump being unable to reduce the flow; in another, 350 gallons, and in a third 150 gallons were obtained; while in two other cases good supplies were got without any estimate of the quantity being given. One farmer went 20 ft. and obtained a small supply; another struck salt-water. The farmers had to sink from 75 ft. to 280 ft. to get the better supplies.

## NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

*South Yorkshire Coal Trade.*—The holidays have had a quieting effect upon the situation, and have given collieries and merchants an opportunity of reviewing the position. The opinion prevails that the outlook is much brighter than for some considerable time past. Railway facilities are becoming more normal in their application to colliery traffic, and it is expected that pits will now commence to work more regularly with the arrival of the fine warm weather. A re-start was made at the collieries to-day, and in almost all cases the report was the gratifying one of the smallness in the number of absentees. There is a heavy demand for prompt deliveries of steam fuel, for works have practically absorbed all floating stocks during the last few days. Collieries, however, are contenting themselves with fulfilling contract accounts, with the result that other prospective buyers are not able to secure supplies. Shipments have not been up to the usual average of the South Yorkshire area, although France has received comparatively large consignments. Inland works are taking good tonnage of gas fuels, but transactions are solely on account of contract. Smalls, nuts, cobbles, and slacks are very hard to obtain, even at top prices, and works are experiencing great difficulty in securing adequate quantities. The house-coal position is becoming easier week by week, and colliery agents and merchants are not now anticipating any serious trouble in this section. Given a continuance of the present fine weather, they are confident that they will be able to wipe off the remaining portion of the arrears which have accumulated. A noticeable feature of late has been the enormous increase in the use of coke for various purposes, and the consequent larger orders have given prices a sharp upward tendency. Quotations:—Best branch hand-picked, 20s. 6d. to 21s. 6d.; Barnsley best silkstones, 18s. 6d. to 19s.; Derbyshire best brights, 17s. 6d. to 18s. 6d.; Derbyshire house coal, 16s. to 17s.; best large nuts, 15s. 6d. to 16s. 6d.; small nuts, 15s. to 16s; Yorkshire hards, 16s. 6d. to 17s. 6d.; Derbyshire hards, 16s. to 17s.; best slacks, 12s. to 13s.; seconds, 11s. to 12s.; and smalls, 8s. to 9s. per ton.

*Iron and Steel.*—After having devoted all the available resources of the local steel industry to the imperative call for munitions, the Sheffield manufacturers are now confronted with the rather serious problem of a shortage of material. The scarcity in the supply of steel has now reached a point when it is giving rise to grave concern in trade circles, and the Government is urged to take strong action to deal with the situation. The restriction on the export of steel ingots, blooms, billets, &c., is regarded as a wise move, but something further in the shape of re-organising the supply is wanted. France and our Colonies have been big customers for ingots, blooms, billets, &c., and it is felt that the authorities may allow exportation to these countries only under very sharply-defined regulations. The consumption of steel for Government purposes alone records an increase almost daily, and there is no likelihood of an early diminution. On the contrary, when many of the new works are in complete running order, there will be an extended use. To-day local makers are employed almost entirely in fulfilling Government requirements. The market retains its settled atmosphere. Foundry iron is again freely asked for, but Lincolnshire and Derbyshire makers seem to concentrate on forge iron, for which there is a very pressing demand. Prices all round are at the maximum. A sharp rise for certain qualities of hematites would have been experienced this week if the Government scheme had not been in operation. Spanish ore is now round about 40s., with delivery, or an advance of 5s. to 6s. on the price the consumer is asked to pay on the Government scale of rates. To recompense makers, therefore, the Government have now to come forward with their promised subsidies. West Coast hematite is marked at 136s. to 140s., with delivery here, and East Coast remains at 128s. 3d. For export purposes makers are receiving fully 12s. above these figures, but the Government subsidies do not extend to this trade. Sheffield's requirements of hematite, especially of mixed and special grades, is advancing, and it is satisfactory to note that deliveries are of an ample description. In the scrap markets prices are easier, steel and wrought-iron scrap being plentiful. The general trade of the city is remarkably active. Agricultural machinery and implement manufacturers have had a very busy month and have been able to execute nearly all orders, despite reduction of skilled staffs. The latest War Office contracts are for enormous quantities of clasp-knives, table-knives and forks, razors, butchers' steels, constructional steel and tools, and electro-plate. The main feature of the overseas business is the large number of indents for machine-knives, drills, saws and tools.

OXIDATION OF STORED COAL.—A somewhat belated reference to experiments made by Alvin Cox with Philippine coal appeared some time ago in the Abstracts of the Journal of the Chemical Society, the original account having been published in the Philippine Journal of Science, of 1912, vol. vii., pages 297-314. The conclusions arrived at seem to confirm previous experiments. When the coal was exposed to air or oxygen in a closed vessel, the gas pressure first decreased and then increased; that would indicate that oxygen is absorbed, but that carbon dioxide is not at once produced and liberated, the first product being some peroxide. The rate of oxidation varied with the amount of previous exposure to air. Oxidation and deterioration were observed in atmospheres of nitrogen and of carbon dioxide. The calorific value of the coal was sensibly reduced by oxidation.

## NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

*The Cleveland Iron Trade.*—The great and growing scarcity of Cleveland pig-iron, together with the great difficulty experienced in obtaining licences for shipments, has reduced trading to very small dimensions. Continental customers are very anxious to place orders, and are prepared to pay very high rates; but their efforts to purchase meets with little success, most of the iron now being made being required for home use. Some little export trade, however, is still passing. The export quotation for No. 3 Cleveland pig may be put at 92s. 6d., but, as a matter of fact, 95s. 6d. has this week been paid for a small parcel, and the figure would readily be paid again if delivery could be guaranteed. For home consumption No. 3 remains at the fixed maximum of 82s. 6d. Holders of Middlesbrough pig-iron warrants still refuse to quote, and have not named a price this month. Buyers offer 82s. 6d. cash.

*Hematite Iron.*—Second hands have no East Coast hematite pig-iron to dispose of, and few makers are in a position to sell for supply earlier than three months ahead. Business in this branch of the staple industry is consequently almost at a standstill. Quotations for Nos. 1, 2, and 3 stand at 122s. 6d. for home consumption, and 140s. for export.

*Shipments and Stocks of Pig-Iron.*—Under conditions prevailing, shipments of pig-iron must be regarded as on a satisfactory scale. This month, to the 26th inst., despatches from the port of Middlesbrough amount to 33,911 tons, as compared with 34,660 tons to the same date last month, and 9595 tons for the corresponding part of April last year. The stock of Cleveland pig-iron in the public warrant stores here now stands at 40,291 tons, of which 37,766 tons are No. 3 quality, and 2525 tons other kinds of iron deliverable as standard. So far this month, 17,166 tons of No. 3 have been taken from, and 147 tons of standard iron added to, the stores, giving a net reduction of 17,019 tons.

*Coke.*—Little new can be reported concerning the coke trade. Demand all round is good, and the output is fully absorbed. Local requirements continue heavy, and further business is reported at 28s. at the ovens for medium blast-furnace kinds, and up to 30s. 6d. at the ovens for sorts low in phosphorus. Foundry coke is put at round about 45s. Gas house coke runs from 27s. to 28s.

*Foreign Ore.*—The situation so far as foreign ore is concerned is still peculiar. Freights in the open market are coming down in consequence of the action of the Government. Steamers Bilbao-Middlesbrough can now be fixed at 21s. 6d., but consumers of foreign ore buying to manufacture iron for home use have the privilege of arranging Bilbao-Middlesbrough freights, through the Government, at 17s.; and as the f.o.b. price of Rubio of 50 per cent. quality is 17s. 6d., the ex-ship Tees price may be regarded as 34s. 6d., though in the open market the quotation is round about 39s. There is no buying, however, except by controlled companies. Very good supplies of ore continue to come to hand. To date this month imports of foreign ore to the Tees amount to 145,644 tons.

*Manufactured Iron and Steel.*—Producers of finished iron and steel are kept working at full pressure on Government work, to the continued exclusion of ordinary commercial business. So short are supplies that the ordinary Easter holidays have been curtailed by most firms. The following are among the principal market quotations:—Common iron bars, 13*l.* 15s.; best bars, 14*l.* 2s. 6d.; best best bars, 14*l.* 10s.; packing-iron (parallel), 10*l.*; packing-iron (tapered), 11*l.* 15s.; iron ship-plates, 11*l.* 10s.; iron ship-angles, 13*l.* 15s.; steel ship-plates, 11*l.* 10s.; steel ship-angles, 11*l.* 2s. 6d.; steel joists, 11*l.* 2s. 6d.; and heavy steel rails, 10*l.* 17s. 6d.—all net.

IMPORTATION OF COMPETITIVE MERCHANDISE INTO AUSTRALIA.—H.M. Trade Commissioner for Australia has furnished the following table illustrating the share of the United Kingdom, the British Dominions and Possessions, and the United States in the importation of "competitive merchandise" into the Commonwealth of Australia, which in the year ended June 30, 1915, totalled 48,867,011*l.*:—

| — | 1913 (Calendar Year). | | 1914 (January to June). | | 1914-15 (Year ended June 30). | |
|---|---|---|---|---|---|---|
| | £ | p.c. | £ | p.c. | £ | p.c. |
| Total .. . | 60,551,516 | 100.0 | 31,256,142 | 100.0 | 48,867,011 | 100.0 |
| Of which, from— | | | | | | |
| United Kingdom .. | 38,285,340 | 63.2 | 19,285,214 | 61.9 | 31,732,974 | 64.9 |
| British Dominions and Possessions | — | — | — | — | 1,899,075 | 3.8 |
| Germany .. | 6,836,441 | 11.4 | 3,592,287 | 11.5 | — | — |
| United States | 7,125,145 | 11.8 | 3,709,393 | 11.9 | 7,480,170 | 15.2 |
| All other countries .. | 8,254,590 | 13.6 | 4,669,254 | 14.7 | 7,804,792 | 16.1 |

From the foregoing table it will be seen that, of the decrease of about 12,000,000*l.* in the total imports of "competitive merchandise" into Australia in the year ended June 30, 1915, as compared with the calendar year 1913, the decrease in the imports from the United Kingdom amounted to 6,500,000*l.*; it should be noted, however, that the percentage of imports from the United Kingdom to the total imports actually increased from 63.2 per cent. in 1913 to 64.9 per cent. in 1914-15.

## NOTES FROM THE SOUTH-WEST.

*Cardiff.*—Little change has occurred in the position and prospects of the South Wales steam-coal trade. The general condition is one of continued tension. The best Admiralty large steam coal has been, to some extent, nominal; secondary qualities have made 49s. to 51s.; Monmouthshire Black Veins, 50s. to 51s.; ordinary Western Valleys, 49s. to 50s.; Eastern Valleys, 44s. to 46s.; best bunker smalls, 28s. to 30s.; and cargo smalls, 19s. to 20s. per ton. As regards bituminous coal, the best households have brought 23s. to 24s.; No. 3 Rhondda large, 48s. to 50s.; smalls, 29s. to 30s.; No. 2 Rhondda large, 40s. to 42s.; and No. 2 smalls, 22s. to 23s. per ton. The latest quotation for patent fuel is 45s. to 50s. per ton. Special foundry coke for export has been quoted at 57s. 6d. to 62s. 6d., good foundry coke at 52s. 6d. to 57s. 6d., and furnace coke, at 42s. 6d. to 47s. 6d. per ton. In iron ore, Rubio was quoted at 39s. to 40s. per ton. The great difficulty in the Welsh coal trade is, after all, the inadequacy of the output. There has been a fairly good supply of tonnage at the docks, and for prompt shipment rates of freight are lower; but stocks have disappeared. At the same time there has been a strong current demand.

*Western Trade Matters.*—The profits of the Sutherland Steamship Company for 1915-16 amount to 306,975*l.*, of which 242,000*l.* is carried to reserve; the dividend for 1915-16 is 30 per cent., as compared with 20 per cent. in 1914-15, and 15 per cent. in 1913-14.—The Swansea Town Council has received a letter from the Surveyor to the Glamorgan County Council stating that the chairman has agreed, on certain conditions, to the laying of a water main on the Mumbles-road.—Mr. Watkin Moss, agent for the Rhymney Iron Company's Rhymney and Pontlottyn Collieries, will be shortly relinquishing his present office for the important appointment of agent at the Lewis-Merthyr Collieries, Hafod.—Exports of Welsh coal from Bristol Channel ports in March were:—Cargo—1,608,161 tons, as compared with 1,923,279 tons; bunker—274,256 tons, as compared with 433,139 tons. Cargo shipments from Cardiff were 725,385 tons, as compared with 1,283,040 tons; and bunker shipments, 182,568 tons, as compared with 296,213 tons.—The Griffiths-Lewis Steam Navigation Company, Limited, will pay an interim dividend of 6 per cent. on May 1.—Lord Muir Mackenzie, in making his first wages award as independent chairman of the South Wales Conciliation Board, has failed to satisfy either side, for the miners have passed a resolution expressing "profound dissatisfaction," while the coal-owners contend that his Lordship has not done them justice.—In consequence of the continuance of the war, the directors of the Lampeter, Aberayron, and New Quay Light Railway state that no report of the working or prospects of the railway can be put before the shareholders. The amount payable by the Great Western Railway Company for the past year is 468*l.*, as compared with 518*l.* In consequence of the higher rates of interest involved by the war, the company has to pay an additional 1 per cent. per annum on an overdraft.—The directors of the important shipping company known as Frederick Leyland and Co., Limited, return the profits of the undertaking for 1915 at 1,441,690*l.*, as compared with 551,637*l.* in 1914. An allocation of 750,000*l.* has been made to the reserve for 1915; a similar allocation was made in 1914. Depreciation allowances amounted in 1915 to 995,007*l.*; in 1914 the corresponding allowances were 314,449*l.* Preference dividends absorbed 176,794*l.* in 1915, as compared with 424,305*l.* in 1914, large arrears having been cleared off in that year. A dividend of 18¾ per cent. is proposed upon the ordinary shares for 1915; in the previous year no distribution was made upon the ordinary capital. The great change observable last year in the position of the ordinary shares was due, of course, to record freight rates.

PERSONAL.—An agreement has been concluded with Mr. Clifford C. Paterson, M.I.E.E., A.M. Inst. C.E., principal assistant in charge of electro-technical and photometric buildings at the National Physical Laboratory, to join the Osram-Robertson Lamp Works, Limited, as director of laboratories for research and technical manufacturing purposes. The arrangement will commence at the conclusion of the war, or before that date, if possible.

THE LATE MR. JOHN JEFFREYS.—Many of our readers will learn with regret of the death of Mr. John Jeffreys, which occurred, after a short illness, on Good Friday, at "Kinburn," Egham Hill, Surrey. Mr. Jeffreys, who was a heating and ventilating engineer, was born on December 30, 1851, and received his primary education at a boarding school at Redhill, Surrey. He was apprenticed to the late Mr. Henry Fuller, architect and mill engineer, of Manchester, from 1867 to 1873, and for four years subsequently was with Messrs. Matthew T. Shaw and Co., constructional engineers, of London, first as a draughtsman, and afterwards as works inspector. After leaving this firm he became assistant manager to Messrs. Rosser and Russell, heating engineers, acting in this capacity until 1881, when he commenced business for himself as a specialist in heating and ventilation. From that time he was responsible for the design and installation of heating and ventilating plants in some hundreds of public and private buildings, including the Admiralty buildings, the Prudential buildings in Holborn, Kensington Palace, H.M. Record Office, the Government laboratories in Clement's Inn, the Surveyors' Institution, &c. Mr. Jeffreys was a member of the Institution of Mechanical Engineers, to which he was elected in 1902. He was also a member of the American Society of Heating and Ventilating Engineers, of New York.

## THEORY AND PRACTICE IN THE FILTRATION OF WATER.*

By WALTER CLEMENCE.

(*Continued from page* 393.)

### 4. CAWNPORE WATER WORKS (FIG. 7).

THE filtering installation at Cawnpore, India, was constructed in 1882, and consisted of three settling-tanks and open sand filters, each 200 ft. by 100 ft. In 1909 there were seven such filters, which were capable of dealing with 4½ million gallons daily at all seasons, when supplied with water previously decanted in the settling-tanks; but to do this it was necessary to employ 140 lb. of sulphate of alumina at 5*l.* 12*s.* per ton for each million gallons treated. The raw water of the Ganges is always turbid, and exceedingly so in the monsoon season and for three months afterwards—that is to say, from July to December inclusive.

In 1910 it was decided to increase the capacity of the installation to 7 million gallons daily, and three schemes were considered:—

(*a*) An increase on the existing lines by the addition of a new settling-tank and five new sand filters, estimated to cost 10,416*l.*

(*b*) Mechanical filters of the gravity type, as "roughing filters," estimated to cost 12,666*l.*

(*c*) The conversion of the installation into a multiple filtration plant by providing degrossisseurs and pre-filters and increasing the average speed on the final filters, at an estimated cost of 11,466*l.*

Comparisons are sometimes made between the cost of various systems of filtration, and these are frequently misleading, as local circumstances are not taken into consideration. It may therefore be of interest to consider the local conditions in connection with the three estimates given above. Mechanical filters are obviously more costly in India than they would be in Europe or America, as they require skilled labour for their manufacture, particularly if special nozzles, gearing, and other devices are employed, and they must be erected in India under skilled supervision. On the other hand, Indian labour is cheap, and ordinary straight brickwork such as is required in the construction of sand filters, &c., can be completed for 10*s.* per cubic yard for labour and materials. Ferro-concrete is expensive owing to the high cost of cement (from 5*l.* 5*s.* to 5*l.* 15*s.* per ton, delivered at inland stations), and to the fact that skilled supervision is required; so that of the above estimates—

(*a*) Is lowest because only brickwork and earthwork were required.

(*b*) Is highest for the reasons already stated.

(*c*) Included a considerable amount of ferro-concrete work and special fittings imported from Europe, which counterbalanced the advantage gained by constructing the walls of the filters in brickwork, and the total cost may be taken as equal to the cost of similar work in Europe.

As to working costs, scheme (*a*) would have cost the same per million gallons as the original plant; (*b*) would have required nearly double the expenditure on sulphate of alumina per million gallons, and with frequent cleaning of the mechanical filters during the monsoon period, night labour would have been necessary.

For the increased water supply at Cawnpore, scheme (*c*) was adopted on the recommendation of Messrs. James Mansergh and Sons, London. The multiple filters and certain modifications to the existing sand filters were completed in the autumn of 1912, and the installation† has been under observation for two seasons. The plan, Fig. 8, annexed, shows the general arrangement of the settling-tanks, degrossisseurs, and pre-filters, and the final filters. The dotted lines show the space which would have been occupied had the installation been enlarged on the original system of working with decanting basins and sand filters. The general arrangements of the original plant have not been altered in any way, and the sand filters can still be supplied from the settling-tanks.

The filters are drained by a double layer of standard bricks arranged over the whole surface of the floor. In the bottom layer the bricks are placed on edge in parallel rows leading towards the collecting drain constructed on the long axis of the basin. These rows of bricks are laid with a space of 6½ in. between the rows. The upper layer consists of bricks on flat side, laid close together at right angles to those in the lower layer. The filtering materials consist of 2 in. of pebbles superimposed by a layer of 4 in. of coarse sand and 2 ft. 6 in. of fine sand. The latter is obtained locally from the bed of the Ganges in the dry season, and is very much finer than the sand usually employed for slow sand filtration. A photo-micrograph of this sand is given, Fig. 13, to be referred to later. Suitable "loss-of-head" gauges are fitted to each filter.

The multiple filters may be supplied direct from the raw-water rising mains or from the settling-tanks. As, however, the full water-level in the latter is only 2 ft. above the level of the inlet to the degrossisseurs, it will be seen that the tanks, which are 10 ft. deep, cannot be used as decanting basins when used in combination with the multiple filters. The arrangement was adopted in order to avoid abandoning existing works representing a considerable capital expenditure. A small canal has been formed in the bank between settling-tanks 1 and 2, Fig. 8, and the bank between tanks 2 and 3 has been cut, so that by admitting water to tank No. 1 it may be circulated through the three tanks in the direction shown by the arrows. Careful experiments have shown that there is no advantage to be gained by this method of working, and the results obtained by supplying raw water to the degrossisseurs are generally better than those obtained with water previously circulated over the surface of the settling-tanks. The reasons for this will be discussed later on.

The multiple filters consist of three series of degrossisseurs, each of four units, and eight pre-filters. The degrossisseurs are cleaned by air supplied from a Root's blower driven by an oil-engine. The pre-filters are at present cleaned by hand, but have been arranged with the dividing walls 28 ft. from centre to centre, on which rails may be placed to carry a travelling bridge with Boistel automatic scrapers, as fitted to similar pre-filters at Paris, Roubaix, and elsewhere. By means of this apparatus* the filters may be scraped with the minimum amount of labour without emptying the basins.

The pre-filters are provided with a special form of drainage block, now largely employed with multiple filters where the speed of the water is somewhat higher than is possible in ordinary slow filtration. Fig. 9, annexed, shows the form of this block, which is made in cement or terra-cotta. The blocks are perforated with small holes at intervals of 1 in. in each direction, so that the water has a tendency to fall vertically through the filtering materials over the whole surface of the filter. When solid blocks or ordinary bricks are employed with sand filters, the water passes in the direction of the joints between the blocks, and experiment has shown that there is a marked improvement in the performance of sand filters fitted with perforated drainage blocks over those with drains formed of solid bricks. A diagrammatic section of the filtering installation at Cawnpore is given in Fig. 7, annexed. The filtering surface is divided as follows:—Degrossisseurs, 12,250 sq. ft.; pre-filters, 33,500 sq. ft.; and final filters, 140,000 sq. ft.

| | Vertical Speed in Feet per Hour. |
|---|---|
| Degrossisseurs Series 1 ... | 21.43 |
| Degrossisseurs Series 2 ... | 12.82 |
| Degrossisseurs Series 3 ... | 7.14 |
| Pre-filters ... | 1.39 |
| Slow sand filters | 0.33 |

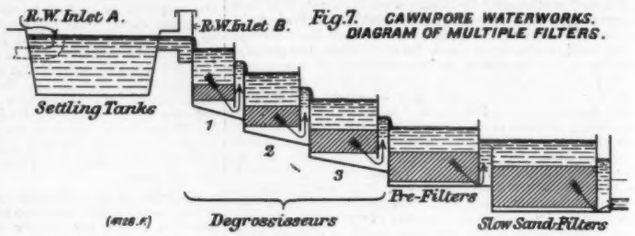



Fig. 7. CAWNPORE WATERWORKS. DIAGRAM OF MULTIPLE FILTERS.

Fig. 8. CAWNPORE WATERWORKS. PLAN OF FILTRATION PLANT.

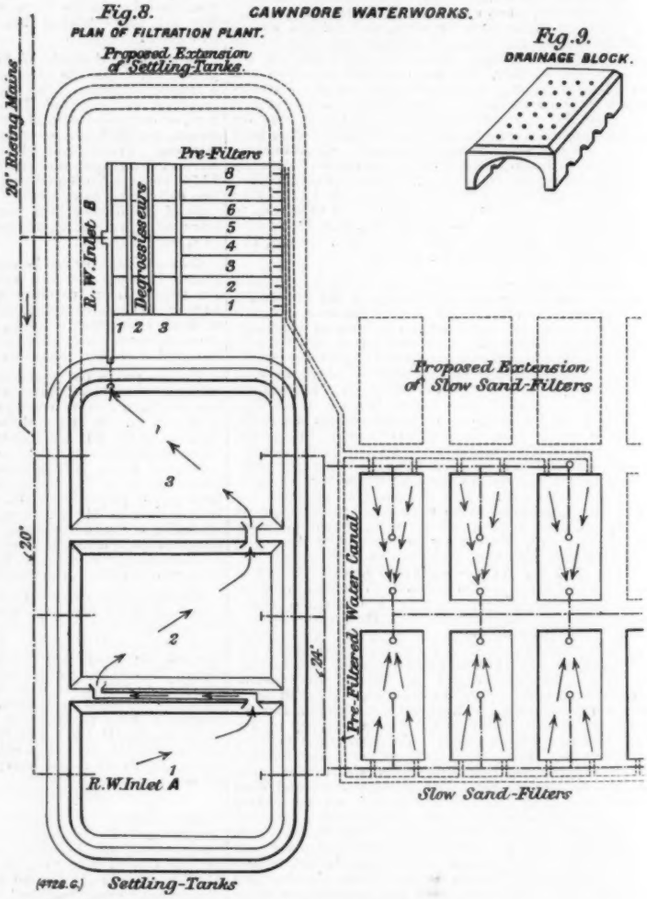



Fig. 9. DRAINAGE BLOCK.



RECORDS OF WORKING OF SAND FILTERS: CAWNPORE WATER WORKS.

| Period. | 1911. Quantity Filtered. | 1911. Filter Days. | 1912. Quantity Filtered. | 1912. Filter Days. | 1913. Quantity Filtered. | 1913. Filter Days. | 1914. Quantity Filtered. | 1914. Filter Days. | Calendar Days. |
|---|---|---|---|---|---|---|---|---|---|
| May 20 to 31 | 55,475,592 | 62 | 51,008,672 | 67 | 51,340,000 | 52 | 62,440,000 | 84 | 12 |
| June | 144,106,352 | 173 | 124,811,909 | 151 | 135,840,080 | 143 | 152,936,600 | 209 | 30 |
| July | 135,113,888 | 195 | 122,692,561 | 169 | 132,800,000 | 154 | 150,258,000 | 206 | 31 |
| August 1 to 12 | 51,725,812 | 76 | 49,039,167 | 63 | 57,760,000 | 59 | 53,280,000 | 81 | 12 |
| | 386,420,644 | | 347,547,309 | | 377,740,000 | | 418,914,600 | | 85 |
| Average per day | 4,546,125 | — | 4,088,791 | — | 4,444,000 | — | 4,928,407 | — | Actual run of filters in 1914 |
| Number of filter days | 506 | — | 450 | — | 408 | — | 580 | — | 1,133 |
| Number of cleanings | 89 | — | 107 | — | 24 | — | 7 | — | 7 |
| Average run of filters between scrapings | 5.68 days | — | 4.20 | — | 17 | — | 82.85 | — | 162 |
| Gallons per filter between scrapings | 4,337,685 | — | 4,243,773 | — | 15,739,161 | — | 59,889,738 | — | 117,007,003 |
| Gallons per square foot between scrapings | 216.88 | — | 212.18 | — | 786.95 | — | 2991.98 | — | 5850.35 |
| Cubic feet per square foot, or height of columns between scrapings | 34.75 | — | 34.00 | — | 126.11 | — | 479.43 | — | 937.55 |

* Paper read before the Institution of Mechanical Engineers on April 14, 1916.

† A full description of these works as modified will be found in ENGINEERING, December 12, 1913.

Careful records of the working of the Cawnpore filters have been kept for many years, and systematic observations of the working of the new installations were made during the hot weather and monsoon rains in 1913 and 1914. These observations were carried out without varying the ordinary routine of the water works in any special way. During 1914 the recorded observations were limited to the period from May 20 to August 12; but as this covers the hot season and the monsoon period to the maximum rise of the Ganges, it is possible, by comparing the records for the same season for four successive years, to estimate the advantages of multiple filtration over

* See ENGINEERING, February 17, 1911.

ordinary sand filtration following decantation. The results are shown by the table on page 412.

In comparing the years 1913 and 1914, it should be stated that all the filters in use were scraped at the commencement of the period of observation in 1913, and the figure of 126.11 ft. represents correctly the average amount of work done by each filter between scrapings, as expressed by the height of a column of water which had passed through. Figs. 10 and 11, on the present page and page 414, record the working of the filters from May 20 to August 12, 1913 and 1914, and the days when the filters were cleaned are marked by shaded vertical columns. It will be noted that in 1914 each filter was cleaned only once, although they had all been working for considerable periods before the observations were commenced. The actual time of working of each filter was:—

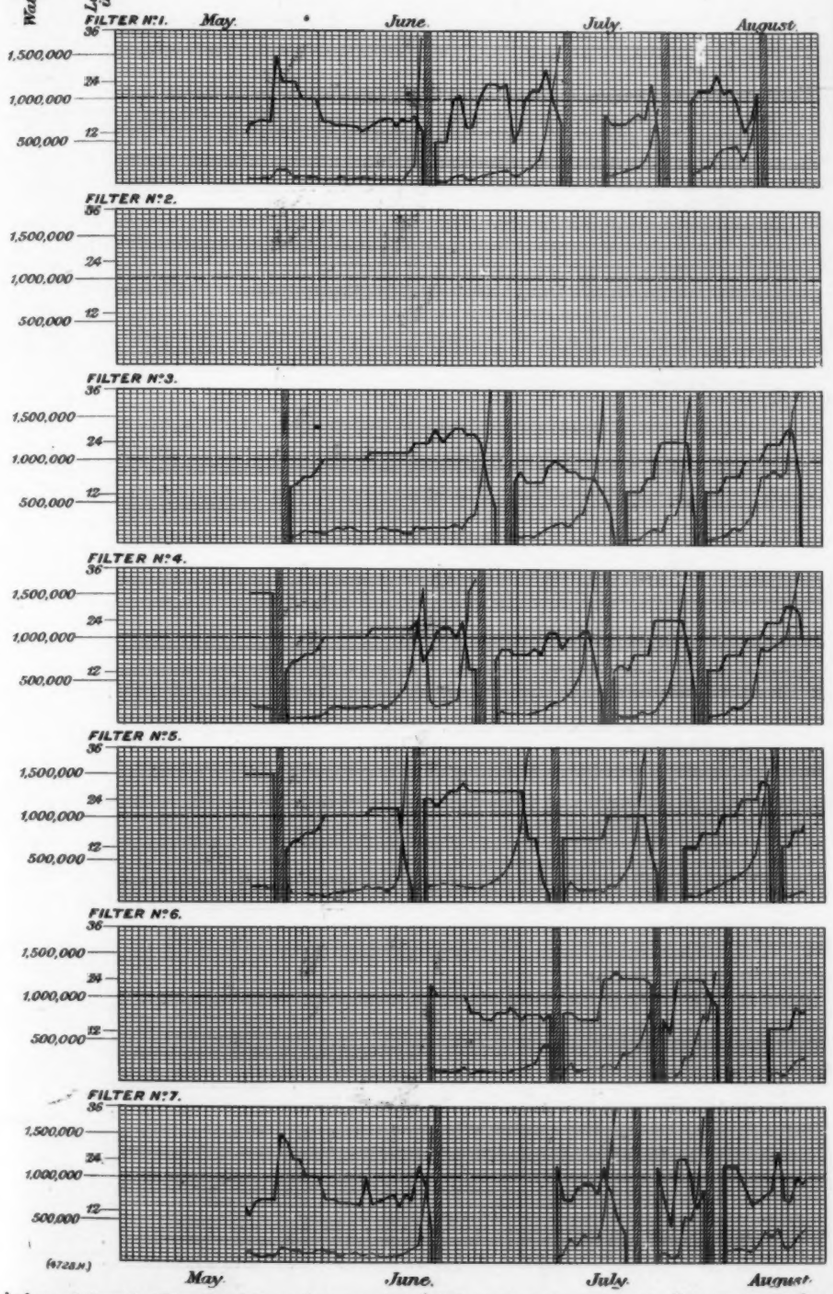
| | Days. |
|---|---|
| No. 1 ... ... ... ... ... ... | 80 |
| „ 2 ... ... ... ... ... ... | 130 |
| „ 3 ... ... ... ... ... ... | 173 |
| „ 4 ... ... ... ... ... ... | 177 |
| „ 5 ... ... ... ... ... ... | 209 |
| „ 6 ... ... ... ... ... ... | 186 |
| „ 7 ... ... ... ... ... ... | 178 |

The average run was 162 days; total filter days worked, 1133; number of scrapings, 7. The average number of gallons passed through each filter was 117,007,093, or 5850.35 gallons per sq. ft. This represents a column of water 937.55 ft. high, and this result was obtained during the most trying period of the year, and without the use of sulphate of alumina or any other chemical. For the whole year the average height of a column of water passed between scrapings is very much higher than this, as, except during the hot weather and monsoon, the final filters do not require cleaning.

*Fig. 10.* CAWNPORE WATER WORKS, 1913.
DAILY RECORD OF WORKING OF SAND-FILTERS

*The Loss-of-head is shown to 36 inches only. In some cases it reached 44 inches. Where not shown, it is to be taken as exceeding 36 inches. The shaded columns indicate the dates when the Filters were scraped.*

*Quantity Filtered.*
*Loss of head.*
*Maximum guaranteed delivery of Filters in combined working.*




Captain C. L. Dunn, I.M.S., who had charge of the observations on the working of the multiple filters at Cawnpore in 1912-13, reported to the Sanitary Board of the United Provinces as follows:—"It is evident that in the period commencing with the end of one monsoon until about one month before the breaking of the next, the final filters require no scraping or cleaning whatever." This shows a great improvement on the condition of affairs prevailing before the adoption of multiple filtration, when the same sand filters had to be frequently scraped at all seasons of the year. In the year ending March 31, 1912, it was necessary to scrape the filters on 270 occasions, distributed over the year as follows:—April, 1911, 33; May, 42; June, 37; July, 22; August, 18; September, 13; October, 16; November, 14; December, 20; January, 1912, 17; February, 20; March, 18. The total quantity filtered during this period was 1,426,860,274 gallons—an average of 5,284,667 gallons for each scraping. As the filters are each 20,000 sq. ft. in area, this gives 264 gallons, or 42.34 cub. ft. per sq. ft. between scrapings as an average for the whole year, compared with 34.75 ft. for the same filters in May to August, 1911, during the hot weather and rains, as shown in the comparative table of four years' working already referred to. The figure of 937.55 ft. for 1914 also covers May to August, so that by comparing the results for the same season in 1911 and 1914, it will be seen that the same filters when forming the final units in a system of multiple filtration in which no chemicals are used, are nearly twenty-seven times as efficient as when dealing with the same water previously treated with sulphate of alumina in settling-tanks.

Referring again to Fig. 10, annexed, and Fig. 11, on page 414, these diagrams show for each of the seven final filters the quantity of water filtered each day, and the recorded "loss of head" required. The horizontal dotted line indicates a delivery of one million gallons per day for each filter, a quantity which represents the maximum calculated capacity of the installation. For local reasons the conditions in 1913 and 1914 were not favourable to obtaining the best results, and in both years there was a serious deficiency in the thickness of sand in the final filters, which should vary between 2 ft. as a minimum to 2 ft. 6 in. as a maximum. The actual thicknesses during the period represented by the diagrams were as follow:—

| Filter. | 1913. Ft. | In. | 1914. Ft. | In. |
|---|---|---|---|---|
| No. 1 ... ... ... | 1 | 0 | 2 | 6 |
| „ 2 ... ... ... | Not in use. | | 2 | 6 |
| „ 3 ... ... ... | 1 | 6 | 1 | 3 |
| „ 4 ... ... ... | 2 | 0 | 2 | 0 |
| „ 5 ... ... ... | 1 | 6 | 1 | 3 |
| „ 6 ... ... ... | 1 | 6 | 1 | 2 |
| „ 7 ... ... ... | 1 | 7 | 1 | 7 |

The number of scrapings during the monsoon of 1913 showed a great improvement over previous years, although the filters were in charge of a new and inexperienced staff, and were worked in a very irregular manner, as shown by the diagram, as, although the total daily demand varied very slightly, the speed of the filters in use was altered from day to day quite unnecessarily. It was found from observation that some of the pre-filters were not yielding the results anticipated, and analyses by Dr. Rideal showed an increase in the amount of free ammonia and oxygen consumed in the water after passing through certain units. This led to inquiries, and it was found that during the construction of the works a considerable quantity of imperfectly washed sand had been placed in four out of eight of the pre-filters. The remaining four pre-filters were filled with carefully-washed sand, which was examined by the author before being placed in the basins.

In the report of Captain Dunn, I.M.S., on his observations on the working of the installation during 1913, the figures given relate almost entirely to the results from pre-filters Nos. 1 to 4, which contained the unwashed sand. During June, July, and August, 196 analyses were made on effluents from these pre-filters, and the average number of bacteria on agar after 48 hours is given as 88 per cub. cm. An analysis from pre-filter No. 6 filled with washed sand gave 10 per cub. cm.

Fig. 10, annexed, shows that so long as the filters are worked at a regular speed, the line for loss of head remains nearly parallel to the line representing the quantity filtered. If, however, a sudden load is put upon the filter, it is found that the increased loss of head required for the higher quantity must be maintained even after the output is reduced, and the filter must soon be laid off for scraping. This appears to be due to compression of the upper layer of fine sand owing to the sudden increase in the load, as it is found that the sand filters in a multiple-filtration plant can be run for very long periods without scraping if the speed is increased gradually when an extra output is required.

From June 9 to August 8, 1913, the installation was supplied with raw water delivered direct on to the degrossisseurs. For the remainder of the period the water was passed through No. 3 settling-tank, but as will be seen from the plan, Fig. 8 (page 412), the distance from the inlet to the settling-tank to the outlet to the degrossisseurs is very short, and, consequently, there was no particular advantage to be gained by this method of supply.

Although some useful information was obtained from the observations made in 1913, the Local Government of the United Provinces desired a more satisfactory test to be made, and requested the author to arrange for further trials in 1914. Before these were commenced, it was decided to cut the banks of the settling-tanks as already described, in order to circulate the raw water over the surface of the three basins. The unwashed sand in pre-filters 1 to 4 was entirely removed and cleaned, but as this necessitated the use of the entire sand-washing plant

for three months, it was impossible to bring the sand in the final filters to its proper thickness. Two filters, however, Nos. 1 and 2, were supplied with the full thickness, 2 ft. 6 in., of fine sand. The settling-tanks were very foul, and unfortunately they were not cleaned before the commencement of the trial.

Under these conditions the installation was placed in charge of a foreman who had previous experience of multiple filtration in hot climates, and he remained in charge during the period covered by the diagram, Fig. 11, annexed. The settling-tanks quickly gave trouble. By the end of May a dense growth of an alga, *Vaucheria sessilis*, almost completely blocked the tanks, which are 10 ft. in depth. As a consequence the water formed channels for itself round this mass of vegetation and scoured the mud from the sloping sides of the tanks. It will be evident that had the water been passed direct to the final filters, the latter would have become choked very quickly with algæ developed from spores carried forward from the growth in the settling-tanks. But, as a matter of fact, the spores were completely arrested by the pre-filters, and for two years there has been no development of algæ on the final filters, which formerly were rapidly blocked from this cause.

As Fig. 11 shows, the work of filtration during May and June was divided evenly over the whole of the seven filters. Any variation in the demand was met by increasing the speed of all the filters, and it will be noted that the lines representing the daily delivery are nearly parallel. The lines showing the "loss of head" show a rise and fall corresponding with the speed of the filters, except in the case of No. 3, the "loss of head" of which increased rapidly from June 12 to June 24, when the filter was scraped after working for 173 days. The thickness of sand on this filter was, however, only 1 ft. 3 in.

After the monsoon had set in, the Government desired the filters to be tested to 75 gallons per sq. ft. per 24 hours, equal to 10,500,000 gallons per 24 hours over the whole of the filters—a very severe test for an installation designed for a maximum output of 7,000,000 gallons. As a result, the whole of the filters had to be scraped shortly afterwards, although the test enabled some useful information to be obtained as to the capabilities of the plant. In the case of filters Nos. 1 and 2—the only filters having the proper thickness of sand—the yield of No. 1 filter was increased from 35 gallons per sq. ft. per 24 hours to 75 gallons with an increase in "loss of head" from 3 in. to 6 in. On July 10 the output was suddenly dropped from 75 to 15 gallons, and as suddenly increased on the following day to 50 gallons. The result of this irregular working was that in a few days the "loss of head" rapidly increased, and the filter was scraped on July 18. It was set to work again on the following day at its maximum designed speed of 50 gallons per sq. ft. per 24 hours, and was kept at this speed until the conclusion of the trials on August 12, when the "loss of head" required to yield the maximum delivery was 3 in. only. Considering the turbidity of the Ganges at this season, the result shown is quite remarkable.

It is to be regretted that the severe test referred to above was applied to all the filters, as it has so far been impossible to ascertain, in a satisfactory manner, the maximum length of run which can be obtained from these filters under normal working conditions. No. 5 filter, though working with only 1 ft. 3 in. of sand, had been working for 209 days when it was scraped on July 22, as a result of the sudden load put upon it on July 10. After scraping it was run continuously at 55 gallons per sq. ft. per 24 hours with a "loss of head" of only 3 in. Careful records were kept of details of the cleaning of the various units of the installation from May 20 to August 12. The quantity of water filtered has already been stated, and from the information obtained during the trials it is possible to calculate the actual labour involved in working the installation for each million gallons of water filtered. In considering these figures it should be remembered that they relate to a period of the year when the river reaches its maximum turbidity, and the working costs per million gallons for the whole year would be considerably less.

*Summary of Working, May 20 to August 12, 1914.*
*Cawnpore Water Works.*

| Dates. | Number of Cleanings of Degrosseurs. | | | Total. | Total Time Cleanings. | | Time during which Engine and Blower were in Use. | | Scrapings of Pre-Filters. | Quantity Filtered. |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | | h. | m. | h. | m. | | gallons |
| May 20 to 31 .. | 23 | 23 | 23 | 69 | 113 | 1 | 45 | 6 | 4 | 62,440,000 |
| June 1 to 30 .. | 39 | 39 | 39 | 117 | 100 | 12 | 80 | 13 | 13 | 152,936,600 |
| July 1 to 31 .. | 15 | 25 | 32 | 70 | 123 | 38 | 42 | 41 | 23 | 150,258,000 |
| Aug. 1 to 12 .. | 5 | 16 | 12 | 33 | 56 | 4 | 23 | 54 | 6 | 53,280,000 |
| Totals .. | 80 | 103 | 106 | 289 | 487 | 55 | 191 | 54 | 46 | 418,914,600 |

In similar installations in Europe, where the degrossisseurs are cleaned by air, the work is easily performed by one man. At Cawnpore, where coolie labour can be obtained for 2 or 3 annas per day, three or four are employed, though the author found that an intelligent Indian mistry could do the work by himself quite as well as a European workman. The above table shows that the actual time occupied in cleaning the units of this part of the installation (that is, from the time the unit was isolated for cleaning to the time it was brought into use again) was 487 hours 55 minutes for 418,914,600 gallons, or 1 hour 10 minutes per million gallons. The time during which the oil-engine and blower were in use was 191 hours 53 minutes, or 27 minutes per million gallons. The blower absorbed about 8 brake horse-power, and a 12-brake-horse-power oil-engine was used.

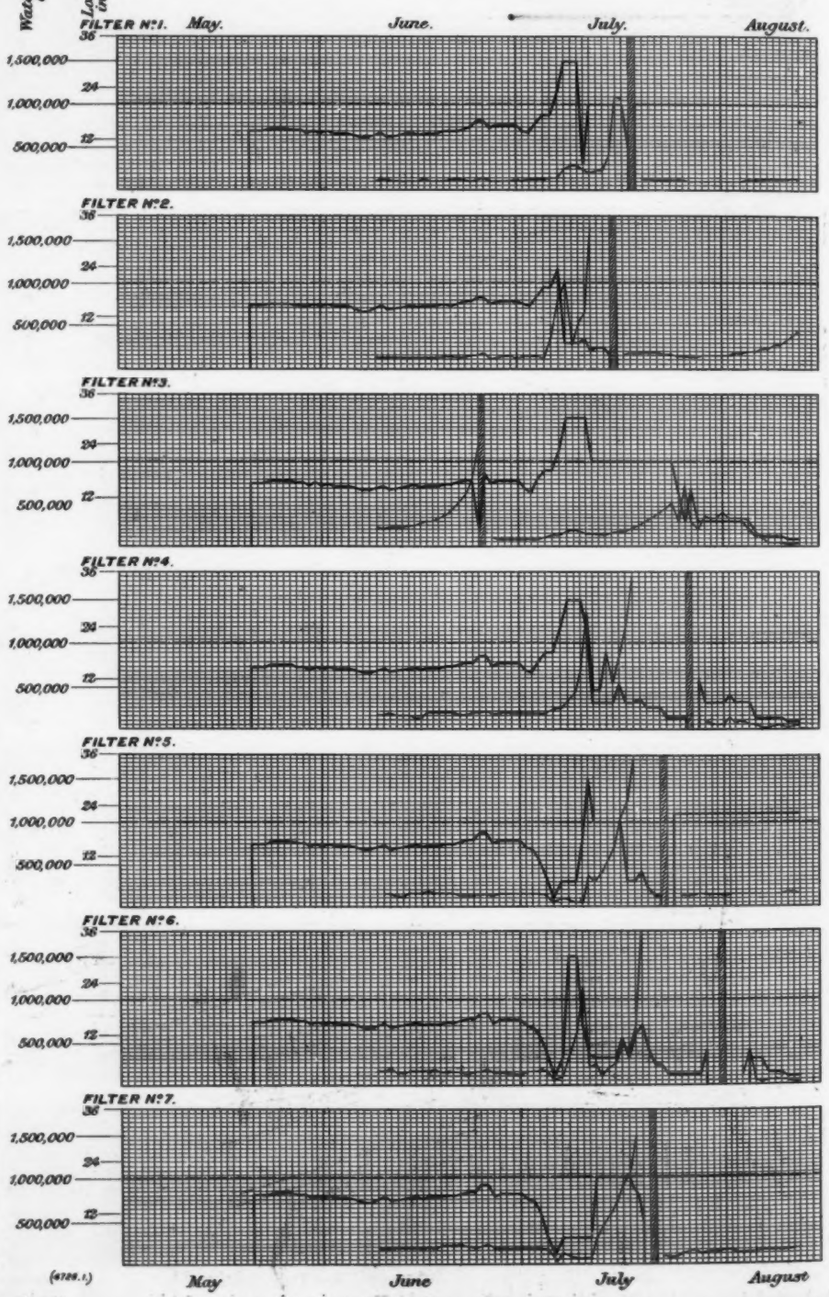
The pre-filters were scraped 46 times, and as the area of each is 4191 sq. ft., it was necessary to scrape 192,786 sq. ft. while filtering 418,914,600 gallons, or 460 sq. ft. per million gallons. Allowing for ½ in. of sand removed at each scraping, it is necessary to remove, wash, and replace 19.16 cub. ft. for each million gallons of water filtered. To estimate the labour required in the final filters it is necessary to go beyond the period covered by the diagrams and tables, and to take the quantity actually filtered from the previous scrapings to the dates when the filters were scraped in June and July.

As already stated, the average run for the seven filters was 162 days and the quantity filtered for each scraping 117,007,093 gallons. The area of each filter is 20,000 sq. ft., so that 171 sq. ft. of surface were scraped for each million gallons filtered, and allowing ½ in. of sand removed at each scraping, it is necessary to remove, wash, and replace 7.12 cub. ft. of sand for each million gallons filtered. It is, however, probable that the figures for the sand filters will show considerable improvement in future, as the run of the filters, on which the average figures are based, was curtailed owing to the severe test to which they were put at the height of the monsoon season. Under the old conditions in 1912 it was necessary to scrape 20,000 sq. ft. of surface for 4,243,773 gallons filtered at the same season of the year—that is, 4713 sq. ft. per million gallons, or 196.25 cub. ft. of sand to remove, wash, and replace for every million gallons of water filtered, against 26.28 cub. ft. from the pre-filters and sand filters combined under the new system.

*Fig. 11.* CAWNPORE WATER WORKS, 1914.
DAILY RECORD OF WORKING OF SAND-FILTERS

*The Loss-of-head is shown to 36 inches only. In some cases it reached 44 inches. Where not shown, it is to be taken as exceeding 36 inches. The shaded columns indicate the dates when the Filters were scraped.*

——— *Quantity Filtered.*
——— *Loss of head.*
——— *Maximum garanteed delivery of Filters in combined working.*




(*To be continued.*)